THE PATROL FRIGATE
COMBAT SYSTEM LAND-BASED TEST SITE

Henry Roger Feeser

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

THE PATROL FRIGATE

COMBAT SYSTEM LAND-BASED TEST SITE

by

Henry Roger Feeser

June 1974

Thesis Advisor: M. G. Sovereign

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The Patrol Frigate

Combat System Land-Based Test Site

by

Henry Roger Feeser
Lieutenant Commander, United States Navy
BSEE, MSEE, Purdue University, 1965

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I. INTRODUCTION

A. GENERAL

The search for better ways to do things in government is not new. However, in Naval ship acquisition, a major attempt at better decision-making is developing.

Both weapons and systems for delivering them have gone through several revolutions in the years since the end of the Second World War. Nuclear bombs are now thousands of times more powerful than those dropped on Hiroshima and Nagasaki. Breakthroughs in missile technology are threatening existing systems. Men in space have provided for military possibilities not thought of two decades ago. Keeping ahead in the technological race is not in itself a guarantee of security in these circumstances. It remains essential to incorporate developing technology into operational hardware and to deploy and use this hardware with skill and intelligence. No amount of production skill or intelligent use can compensate for significant shortcomings in the development, test, and evaluation of the emerging hardware. These important first steps will be explored in this thesis.

In parallel with the technological revolution in weapon systems in the past few decades, we have seen the costs of building and maintaining U. S. Naval ships multiply to astounding heights. The magnitude of these costs is emphasized by the recognition that overhaul and modernization of

computerized missile ships now is often more expensive than procurement costs of ships in the past. In the fiscal-year 1975 Navy budget of $29.6 billion dollars, over $3.6 billion is allocated to the procurement of six classes of Navy vessels. The process of procuring ships is the longest, most complex and greatest in dollar volume, of any in the Defense Department. The cycle from concept to delivery of a new ship may require five to ten years, with technical improvements evolving the whole time.

Weapon systems procurement functions are located at the highest organizational levels in the Services and involve concentrations of the top technical, procurement, test, and evaluation talent. This has been driven by an iterative process whereby the accelerating state of the art has driven the design methodology, management requirements, and subsequently the costs. Program management has been continually revised in an effort to keep stride with this process and ensure the best ships possible while keeping effective cost control. Thus the process described in this thesis consumes major portions of the resources of the Navy.

Previous to World War II, the Navy did much of its own design and development and even some production. But after the war the Navy lost much of this in-house capability. Consequently, the Navy has of necessity become increasingly reliant upon industry for almost every aspect of weapon design, development, test, evaluation, and production. The Navy has shifted its thinking over the years from an absolute autocratic

control of this process in an internal environment, to a more tenuous and democratic committee control in a largely external contractor environment -- one that is much more in the public eye. Unfortunately, the Navy hasn't made this transition smoothly. Within this context, one area which has not kept pace and is sorely in need of a quantum improvement is the development and management of test and evaluation programs. These should be structured to assist top management in making procurement decisions and to reduce the uncertainties surrounding these decisions.

Test and evaluation of proposed new weapon systems is one of the Navy's key controls in the complex process of acquiring today's multi-billion dollar systems. Testing at decisive stages of development shows where problems exist and helps Navy managers to make better decisions affecting future production and purchases of weapons than would otherwise be possible. The test and evaluation of emerging systems within itself involves uncertainty however. "How much is enough?" must be answered for testing itself. It is apparent that many of the problems of managing a test and evaluation program have important economic aspects.

The fundamental problem of how much to spend on a test and evaluation program is an allocation problem within the ship acquisition program. Economic theory tells us that we "should" continue to spend on test and evaluation until the marginal gain from the expenditures is just equal to the gain from expenditures elsewhere. But in the case of test and evaluation, this formula is peculiarly difficult to interpret or apply. The gain

is much more uncertain -- much harder to predict with accuracy -- than the gain from, say, an additional fighter defense squadron with aircraft of known performance. This is particularly true of developmental test and evaluation, where the product, if any, will be mostly knowledge -- and knowledge usually far removed from its practical end use. Rather, its purpose is one of facilitating the evolution of the ship system itself.

Rapid advances in electronics and computer technology have had a profound effect on the complexity of shipboard systems and the test and evaluation needed to support the procurement of these systems. There is a definite need in the Fleet for ever-increasing speed and accuracy in shipboard data processing to meet more sophisticated, high-speed threats. As a result, the key weapon and sensor systems are utilizing digital interfaces and processing to as great an extent as possible. The cost and complexity of the equipment and a movement toward human-engineered ships does not allow us to keep the luxury of back-up and casualty mode operation for many of these functions that we had formerly enjoyed. The demands for greater maintainability and reliability are also forcing increased digitalization. The result is a level of hardware and software integration never previously encountered in a ship system.

B. THE PATROL FRIGATE PROGRAM

The Patrol Frigate (PF 109) Class, for example, will have digital fire control systems in the missile, gun and antisubmarine warfare areas, all linked to command and control within a centrally-located

computer complex. To complicate matters further, at the time the PF program was being formulated, DOD policy regarding major weapon-systems development, acquisition and test was being drastically changed. In a memorandum issued in the Spring of 1970, Deputy Secretary of Defense David Packard indicated that experience with the Total Package Procurement approach to development and acquisition of major systems was unsatisfactory; that it should be used with caution; and that a new policy would soon be established. The new policy took the form of DOD Instruction 5000.1 which outlined the "Fly-Before-Buy" approach. Essentially this new approach requires the services to develop and demonstrate the operability of a weapons system by actual test prior to the commitment of funds for mass-production of any major system. Progress in meeting this requirement is reviewed by the Defense Systems Acquisition Review Council (DSARC) at discrete stages during development. DSARC determines whether the system is ready to advance to the next stage. It then makes recommendations to the Secretary of Defense concerning funding of the next stage and follow-on procurement.

The very design of the PF evolved in parallel with emerging "Fly-Before-Buy" policies within DOD. At the CNO/SECNAV level it was soon realized that it was impractical from a cost and procurement schedule basis to adhere to the letter of the law of emerging policies. Tradeoffs were made such that adequate initial test and evaluation for subsystems is to be demonstrated prior to large-scale ship production.

Additionally, critical ship system integration is to be demonstrated at shore-based test sites. In effect then, we have swung from "Total Package Procurement" to "Fly-Before-Buy" with fewer paper solutions and more actual hardware testing, hardware proofing and prototyping at the system, subsystem, and component level.

As early as the concept exploration phase of the PF procurement, it was realized that weapon selection and subsequent test and evaluation would be a controlling influence on the eventual size as well as on the ship cost of the PF. The Ship Acquisition Project Manager (SHAPM), PMS 399, has identified the integration of the combat system as a critical task in the PF acquisition effort. In conjunction and compliance with emerging DOD test and evaluation requirements, the PF program has been structured specifically to provide for an extensive test program which should substantially reduce technical, cost, and schedule risks. The information obtained from an evaluation of combat-system test data will be a major factor in the final decisions on procurement of follow-ships at CEB, DSARC, and Congressional levels.

Because of its critical nature, the combat system integration effort will be decoupled from the time-critical events of the shipyard and conducted at a land-based test site. The land-based test site will contain an installation duplicating, insofar as possible, the shipboard installation of all sensors, computing equipment, weapons and related subsystems. Interface equipment will be included. Major factors in achieving full

utilization of the integrated system which are to be demonstrated at the land-based test site are envisioned to be computer program debugging and physical, electrical and mechanical compatibility. Both of these are traditionally troublesome areas in complex ships.

C. SCOPE OF THESIS

The major objectives of this thesis were: to investigate and analyze emerging weapon system procurement, test, and evaluation policies within DOD and the Navy Department; to document efforts within the PF development process in view of these policies; and to gain insight into the use of a combat system land-based test site in implementing these policies in the procurement cycle.

II. FROM ROCKS TO COMBAT SYSTEMS

A. BACKGROUND

Man, in his desire for a quicker means of destroying an enemy's capacity for waging war, has continually increased the complexity and destructive force of the weapons in his arsenal. From the era of the rock-throwing caveman, weaponry has now evolved to the era of nuclear-powered ships and sophisticated guided missiles. Early in the history of the Navy, the importance of forward-looking weapon system acquisition was recognized by the organizer of the Navy Gun Factory, John Adolphus Dahlgren, when he stated, "If the Navy be, indeed, the right arm of defense, her guns and ordnance ... are the main sinews and arteries, the neglect of which soon render it feebled and palsied."[1]

Rightly called the "father of naval ordnance," Dahlgren revolutionized the science of ordnance with his original work and set standards for other navies. In 1850 he urged construction of frigates armed entirely with heavy guns, anticipating the dreadnaughts of the next century. A blue-water sailor as well as a scientist, Admiral Dahlgren brilliantly commanded a powerful naval force through two years of arduous wartime service during the Civil War, leaving behind him an example of productive study and gallantry in action.

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[1]Memoirs of John A. Dahlgren, 1891, by Madelin V. Dahlgren.

Why the history? The point is that in the early days of weapon acquisition, test, evaluation and operational use, it was not all that unusual for Navy personnel to recognize a need for an improvement or new weapon, to design and manufacture the weapon within the Navy establishment, and for the conceivers and/or producers to take the weapon to sea for test and evaluation. If a deficiency in ordnance design was noted, it was often corrected on the spot by shipboard gunners.

To a certain extent, a similar path was followed in the introduction of electronic devices to naval warships. Radio was developed as a result of the intense desires of men to exchange intelligence as rapidly as possible over long distances without physical interconnections. Until the present century, a ship's isolation was complete once she navigated out of port and sailed over the horizon. Of course, ships in company or in passing "spoke" to each other by voice hail, or signal flags by day, and lanterns at night. But once at sea, orders or instructions from higher commands not in company could not be easily altered. For want of better communications, major battles have been fought after peace treaties were signed.

The U. S. Navy, in keeping with its traditional scientific leadership, early recognized the impact of radio on naval operations. Only by such means of communication could far-scattered forces be effectively directed. Admiral Bradley A. Fiske, while a lieutenant, experimented with "electronic communication" on naval vessels in 1888, many years

before Marconi's successful application. During Fiske's investigations, he discovered the principles of degaussing ships as a protection against mines (used widely in World War II), and designed a system of radio control of torpedoes which forms the basis for the modern "radio" guided missile. Thus in the early days of electronics, Navy personnel often followed advanced concepts from a glimmering thought to useful hardware aboard ships.

Prior to World War II, ordnance, electronics and communications were more or less separate and individual functions aboard ship. A new gun or electronic (radio) device could be developed, tested, evaluated, and placed in an operational status aboard ship in relative isolation. That is, weapons were weapons, and radios were radios, and there was little marriage between them.

During the 1930's the governments of Great Britain, the United States, and Germany fostered experiments to create a reliable detector that would locate airplanes not visible to the naked eye. The sound-detectors that had been used for this purpose had become almost useless when the increasing speed of airplanes made it necessary for the gunners to "lead" their direction indicators by 20 degrees or more when firing. Although all three of the countries named were active in the development of radar, Great Britain led because it had the most to fear from air attacks.

Radar was soon integrated with the fire control function of gunnery, since it provided a more sure method of determining ranges than optical

instruments and worked regardless of night, fog, or distance. The marriage of radar to gunnery in the area of fire control and the increasing swiftness of naval engagements, especially sea-air battles, brought into existence a new organization, the CIC or combat information center, on warships. The CIC filtered out the multitude of items of information that came in from the radar, spotting planes, sonar, and so on, reducing them to manageable proportions to enable the commanding officer to make intelligent decisions.

Supersonic jets, greater threats from other surface units, and advancements in submarine warfare soon overran the man-machine interface present in CIC during much of World War II and the Korean War. Computers were introduced as an aid to commanders in their information gathering and decision-making processes. Application of the computer in naval weapons systems has advanced to the point where man-machine interface has been minimized to the point where in many instances human resources are no longer required.

Throughout the course of history, the development of weapons has been extremely slow. It is said that until 1000 A.D., weapons had a useful life of about 400 years. Today, the useful life span of a weapon system may only be from 3 to 7 years before rendered obsolete by emerging technology or enemy advances. The design, development, test and evaluation phases of weapon-system acquisition have become increasingly important as the useful life span of weapons has decreased.

It is the speed of development, test and evaluation which largely determines the extent to which the system design incorporates the latest technical advances.

B. WEAPON SYSTEM CONCEPTS

The concept of a weapon system has come into being rather recently in naval history, evolving from ordnance, radio, radar and fire control to the point where a weapon system is made up of a number of unique, specialized components which must be integrated to achieve overall effectiveness. Ordnance Pamphlet (OP) 3000 defines a weapon system as "a collection of integrated components or subsystems which perform the interrelated functions necessary to render the desired effect on the enemy." Recent thinking has further integrated weapon systems into naval ships by dividing a ship into a containment system and a combat system. The containment system is viewed as the ship structure and related housekeeping systems, e.g., the hull, damage control, laundry and messes. The combat system is thought of as being the command and control, navigation, external communications, weapon and other supporting systems used directly for target surveillance, target recognition, electronic countermeasures, weapon delivery, weapon handling and storage, and weapon safety. The complete combat system does not consist of the physical equipment alone, but also of technical manuals, training plans and equipment, spare parts, of an optimum employment

doctrine, and the human resources necessary to pursue objectives. Weapons system procurement thus includes concurrent development, test and evaluation of all of these items.

III. EVOLUTION OF TEST & EVALUATION CONCEPTS

A. UP TO McNAMARA AND 1961

From the perspective of Test and Evaluation, the weapon acquisition strategies which evolved within the Navy prior to the appointment of Secretary McNamara in 1961 suffered from a number of problems which paralleled those of planning and budgeting. For example, funds for adequate testing were often not available and test results were seldom available in time to influence the major program decisions which shaped the character and quantity of systems. Procurement of weapon systems was production orientated, with test and evaluation taking the back seat to hardware. Each major weapon subsystem was tested individually prior to shipboard deployment. The first time all interacting subsystems were tested as a single functioning system was after shipboard installation. Increasing system complexity and the requirement for the combat system to function under semi-automatic central control in a shipboard environment was not mirrored in total system test and evaluation concepts.

In conjunction with shortcomings in test and evaluation concepts, the government in the late 50's and early 60's regarded military procurement efforts as very risky and therefore used the cost-plus-fixed-fee type of contract for this work. During this period centralized governmental planning and direction of military procurement programs were lacking. As a result, many duplicative approaches were funded to

meet poorly conceived military requirements. Programs were initiated without adequate evaluation of the time and cost required to complete them, and performance and reliability requirements were often left to the contractors to define after contract awards had been made. In this atmosphere, schedule slippages and cost overruns of 200% to 300% were typical, and many programs were cancelled before completion because of infeasibility, obsolescence, or excessive cost.

Elements of each service sought funding for programs that would enhance their own military role. Funds usually being in short supply, the procuring service would often encourage the contractor to bid unrealistically low by revealing the amount of money available for the project. In an effort to get hardware out of the factory and aboard ship, test and evaluation programs were often shortened or completely chopped from the procurement cycle. It remained for untrained sailors on board ship to discover that the weapon systems fell short of filling the requirement for which they were originally procured.

The nature of the contractors with whom the services were dealing also were going through changes. In years past, the Navy dealt with contractors who were actually producers. These were real technical people with responsibility but who were on a first name basis with Navy personnel. These people had been at sea and knew the bow from the stern of a ship. The Navy could expect technical performance from men like this who felt a strong personal pride in any equipment they provided.

During this time period, for a variety of complex reasons, most defense contractors were moving toward conglomerate corporations. The Navy no longer talked with owner-operators. They talked to corporate executives who often knew little about building ships and weapon systems but were interested in cash flow and return on investment. They were often lacking in detailed technical knowledge of weapons, having reached their management position through other channels, but were very good about discussing concepts such as schedules and costs. They may have known the cost impact of a proposed change, but they didn't know the other ramifications.

Since the contracts were the cost-plus-fixed-fee types and the contractor was assured of recovering his full cost, the contractor often was willing to bid well below the probable final cost in competing for the contract. Both the service and the contractor hoped that after the initial money was spent, the government would be so committed to the program that it would provide successively greater increments of funding rather than cancel it. A similar "liars contest" was conducted regarding the project schedule. If the government wanted the equipment by a certain date, the contractor was willing to commit himself to provide the equipment by that date, regardless of the chances of doing it, again often at the expense of test and evaluation, which was the final activity in the schedule.

B. McNAMARA'S POLICIES

When Robert S. McNamara became Secretary of Defense, he launched a series of changes in the government's decision-making processes and in weapon-system contracting procedures which profoundly and rapidly affected the defense industry environment. He began by centralizing much of the authority to initiate programs in the Office of the Secretary of Defense. To avoid duplication of procurement in the services, he utilized the concept of Systems Analysis, which was to select among competing programs. He placed government budgeting on a five-year basis to permit appraisal of the total financial impact of major programs spanning a number of years. He required contractors to plan their activities thoroughly before the government approved the program funding.

To dissuade contractors from accepting unrealistic contracts and to encourage efficient performance after award, McNamara curtailed the use of cost-plus-fixed-fee contracts. To motivate contractors to design weapon systems having low production costs, and to discourage them from bidding low on weapon system contracts in the hope of making it up in the subsequent sole-source production contracts he authorized the use of "Total Package Procurement" contracts in which the development, test and evaluation, production, and support of weapon systems were competitively procured in a single, multi-year contract.

The Pentagon's new policy was bound to cause great difficulties for the defense industry, accustomed as it was to the old way of doing business. Its problems were complicated by the failure of the Defense Department to adapt completely to its changed role. DOD was weak, for example, in estimating program costs and in predicting how much test and evaluation was necessary to reduce uncertainty in weapon system procurement to a manageable level. Policies established at high levels were not understood, implemented, or enforced at lower levels. The bureaucracy was doing a very poor job of defining the documentation necessary to implement the new procedures.

Because the contractors were accustomed to telling their customers what they wanted to hear about delivery dates, program cost, and product performance, they found it almost impossible to bring themselves to challenge the government's preliminary plans. Yet this kind of confrontation was one of the major objectives of the contract definition phase of Total Package Procurement.

Contractors, would, for example, consider the Pentagon's requested delivery dates as sacred, and tried somehow to schedule the design, development, test and evaluation, and production into the available time. They tended to make cost and technical appraisals by automatically accepting government requirements for the various elements of the system and program -- rather than by estimating each element's cost or technical performance individually, then summarizing them to

obtain an independent appraisal of total system performance and total program cost.

As a result, the weapon system procurement plans were not much more realistic than those formerly submitted by contractors, when they simply told the services whatever would help them "sell" the programs further up the line. As in former years, when schedule and/or cost crunches arose, one of the first areas to be lopped off was the area of test and evaluation in an effort to get the hardware delivered. Paper studies were often substituted for actual test and evaluation of end product items. In short, contractors often signed fixed-price, total-package contracts at prices below the expected cost, containing risks that were not thoroughly appraised, and for which they lacked the management disciplines necessary to perform the work in an efficient manner.

C. GET WELL PROGRAMS

Efforts to correct problems related to test and evaluation (T&E) were started in the late Sixties. These efforts were greatly accelerated with the Report of the Blue Ribbon Defense Panel (BRDP) of July 1970, and various T&E measures taken during calendar 1971 to deal with the issues raised by the BRDP.

1. The Blue Ribbon Defense Panel's Findings

The following excerpt is quoted from the BRDP section on "Operational Testing and Evaluation," pages 88-91 of the report of 1 July 1970.

Everyone seems to agree that Operational Testing and Evaluation (OT&E) is very important; however, there are significant differences of opinion as to what it encompasses, what its proper objectives are, and what organization and methods are necessary to accomplish it most effectively.

It has been customary to think of OT&E in terms of physical testing (under various designations such as operational suitability testing, employment testing, service testing, or field experimentation). It is essential to recognize that the primary goal of OT&E is operational evaluation, and that while operational testing is very important it is only one method of evaluation. To be effective, OT&E must be a total process, using all appropriate methods of evaluation, which spans the entire cycle of a system from initial requirement until it is phased out of the operational forces. If OT&E were limited to physical testing, it would lose much of its opportunity to contribute to decisions on whether to produce a system, and would seldom be able even to influence the system's characteristics and capabilities in any major way.

Much OT&E does, however, involve physical testing and, therefor, it is important to distinguish between "functional" testing and "operation" testing.

Functional testing (often engineering testing) ((termed "Development Testing" in this Guide)) is done to determine how well various systems and materiel meet design and performance contractual specifications -- in other words, whether they meet technical requirements.

By and large, functional testing in and for the Department of Defense appears to be well understood and faithfully executed. Serious policy deficiencies are not apparent, and such failures in functional testing as occur can be primarily attributed to lack of technical competence, oversight, or procedural breakdowns. Functional testing is not considered to be a major problem area.

Operational testing, on the other hand, is done to determine to the extent possible whether such systems and material can meet operational requirements. It must provide advance knowledge as to what their capabilities and limitations will be when they are subjected to the stresses of the environment for which they were designed (usually combat). Operational testing must take into account the interface with other systems and equipment, tactics and techniques, organizational arrangements, and the human skills and frailties of the eventual users.

There has been an increasing desire, particularly at OSD level, to use data from OT&E to assist in the decision-making process. Unquestionably, it would be extremely useful to replace or support critical assumptions and educated guesses with quantitative data obtained from realistic and relevant operational testing.

Unfortunately, it has been almost impossible to obtain test results which are directly applicable to decisions or useful for analyses. Often test data do not exist. When they do, they frequently are derived from tests which were poorly designed or conducted under insufficiently controlled conditions to permit valid comparisons. It is especially difficult to obtain test data in time to assist in decision-making. Significant changes are essential if OT&E is to realize its potential for contributing to important decisions, particularly where the tests and the decisions must cross Service lines.

The Blue Ribbon Defense Panel made three recommendations on improvement of T&E. While subsequent actions do not constitute rote implementation of the letter of specific recommendations, they do constitute substantial implementation of their spirit. BRDP recommendations called for establishment of a "Defense Test Agency" under the control of an Assistant Secretary of Defense for Test and Evaluation. The rationale of these recommendations was (1) to make sure that adequate testing was accomplished by an agency not under the control of the people who were attempting to "sell" the system being tested and (2) to provide an unfiltered channel for test-based information into the major program decisions made by the Secretary of Defense at DSARC I and DSARC II. A third recommendation called for a separate program category for T&E. This measure was designed to prevent the use of funds required for an adequate T&E to cover development cost overruns.

2. Mr. Packard and the DSARC

One of the first things that Mr. David Packard of Hewlitt-Packard realized when he came into DOD was the necessity for clarifying the responsibilities of the Secretary of Defense and his office vis-a-vis those of the Service Secretaries and their staffs. He quickly decided that there was a need for a very simple modus operandi by which the OSD would establish policy and make decisions at appropriate points and the military services would carry them out. Once having done its part, the OSD would step back out of the way of the performing organization. Furthermore, the various OSD offices, such as that of the Director of Defense Research and Engineering and the Assistant Secretaries for Installations and Logistics, Systems Analysis, and Comptroller, should lay out their spheres of responsibility and authority, subject, of course, to Mr. Packard's approval.

In a Deputy Secretary of Defense Memorandum dated 28 May 1970 entitled "Policy Guidance on Major Weapon System Acquisition," Mr. Packard required the Services to develop and demonstrate the operability of a weapons system by actual test prior to the commitment of funds for production of a major system. Progress in meeting this requirement is reviewed by the Defense Systems Acquisition Review Council (DSARC) at discrete stages during development. DSARC determines whether the system is ready to advance to the next stage, and then makes recommendations to the Secretary of Defense concerning

funding of the next stage. Generally these reviews are held prior to initiation of 1) engineering development, 2) prototyping, and 3) system production.

When the council considers the first two of the three major decisions, the Director of Defense Research and Engineering chairs it. For the third decision, he serves as a member, while the Assistant Secretary of Defense for Installation and Logistics, who is responsible for production and development, becomes the chairman. At this point, the Director of Defense Research and Engineering is the seller and the Assistant Secretary of Defense for Installation and Logistics is the buyer.

After the DSARC finishes its deliberations, the Deputy Secretary of Defense makes a decision which holds unless new evidence arises to change it. For example, usually the program goes ahead smoothly until it runs into some kind of cost, schedule, or system-performance problem. If any such difficulty causes the breaching of established thresholds (i. e., tolerances on critical program parameters agreed upon by the Secretary of Defense and the responsible Service Secretary), the program comes up for another examination by the Secretary of Defense. Barring that kind of situation, the programs are run by the Services and the Secretary of Defense stays out of them -- except to keep informed on their status through regular program reviews and Selected Acquisition Reports.

In his memo of 11 February 1971, "Conduct of Operational Test and Evaluation," Secretary Packard wrote:

> Although each Service now has a somewhat different way of organizing for operational test and evaluation, it is apparent to me that this function can best be performed by an agency which is separate and distinct from the developing command and which reports the results of its test and evaluation efforts directly to the Chief of the Service. Moreover, within the Service headquarters staff, there needs to be an office with a clear OT&E identification to provide staff assistance directly to the Service Chief and to provide a headquarters focal point for the independent OT&E field agency. Thus, at the completion of Operational Service Testing in the Army, OPEVAL in the Navy, and Cat III testing in the Air Force, I would expect that the respective Service Chiefs would have a clear picture of the operational suitability of a weapon system for Service use, to include its principal deficiencies and limitations and the corrective actions required prior to full-scale introduction into the force. Accordingly, each Service is requested to restructure its organization for OT&E along the lines specified above.
>
> As a second step, I am establishing a Deputy Director for Test and Evaluation within ODDR&E with across the board responsibilities for OSD in test and evaluation matters. This office will review and approve test and evaluation plans prepared by the Services and will provide an assessment of results obtained.

In his memo of 21 April 1971, Secretary Packard prescribed measures to ensure the flow of T&E information into major program decisions.

> The DCP format focuses attention on relevant technical and operational information through the identification of achievement milestones. The function of the test and evaluation milestones is to insure the availability of critical technical and operational data prior to each major Defense System Acquisition Review Council action.
>
> The newly-established Deputy Director, Defense Research and Engineering (Test and Evaluation) will receive from the Military Departments for review and comment, during the drafting of the initial DCP, a brief (1-4 pages) statement of the critical questions or issues which the development tests will address. The coordinated DCP for DSARC Milestone I (Program Decision) will contain a condensed

version of the critical questions or issues as well as the proposed schedule of the major development test milestones for addressing them.

The DCP for DSARC Milestone II (Ratification Decision) will refine the critical questions or issues associated with development test and evaluation and will extend the process to include the critical questions or issues to be addressed during initial OT&E and the test schedules therefor. At such time as the OT&E test plan is available, the Deputy Director will review it to insure that the critical questions or issues are adequately covered.

Prior to the DSARC Milestone III (Production Decision) the Military Departments will provide the Director of Defense Research and Engineering with an assessment of the test results in terms of response to the initial questions or issues previously identified. The Deputy Director, Test and Evaluation, will review this assessment and provide an independent recommendation to the DSARC Milestone III meeting.

3. Department of Defense Directive 5000.1

Department of Defense Directive (DODD) 5000.1, Acquisition of Major Defense Systems, the cornerstone of the Navy's comprehensive new acquisition policy, was the culmination of a concerted effort to identify the underlying causes of unsuccessful acquisition experiences and to prompt whatever improvements were deemed necessary. While DODD 5000.1 addresses major weapon system programs, the management principles on which it is based are applicable to all programs. The directive formally establishes the DSARC. It takes a strong position on the decentralization of high-level controls in regard to the day-to-day aspects of acquisition, and it establishes the concept of a powerful, less encumbered program manager. Finally, DODD 5000.1 establishes a number of considerations for major weapon system acquisition.

In the area of test and evaluation, paragraphs III. C. 5 and 6 apply directly and are as follows:

5. Technical uncertainty shall be continually assessed. Progressive commitments of resources which incur program risk will be made only when confidence in program outcome is sufficiently high to warrant going ahead. Models, mock-ups and system hardware will be used to the greatest possible extent to increase confidence level.

6. Test and evaluation shall commence as early as possible. A determination of operational suitability, including logistic support requirements, will be made prior to large-scale production commitments, making use of the most realistic test environment possible and the best representation of the future operational system available. The results of this operational testing will be evaluated and presented to the DSARC at the time of the production decision.

4. <u>More Guidance From Mr. Packard</u>

Secretary Packard's memo of 3 August 1971, "Test and Evaluation in Systems Acquisition Process," amplified the guidance of his 11 February and 21 April memos in part as follows:

The objective of the overall operational test and evaluation effort for any program is to aid in providing at major decision points in the acquisition and development process the best information possible at that point in time as to: the military utility of the prospective system; its expected operational effectiveness, operational suitability (including reliability, logistic, and training requirements); need for modification; and the organization, doctrine and tactics for system deployment. For programs intended for acquisition, phases of operational test and evaluation must be successfully executed in a timely manner to provide needed information as required.

New acquisition programs requiring DSARC processing, or those which are currently in their early stages, will be so executed that an initial phase of operational test and evaluation will be accomplished prior to the major production decision to assist in estimating system operational effectiveness and suitability before that decision.

a. This initial operational test and evaluation will be accomplished with operational personnel in as realistic an operating

environment as possible and, where practical, will use pilot or early production items.

The accomplishment of initial operational test and evaluation as a prerequisite for production decision does not obviate the necessity for completing operational test and evaluation when the production articles are introduced into the operating forces.

5. <u>From the Deputy DDR&E (T&E)</u>

In a memorandum for the Assistant Directors, the Deputy DDR&E(T&E) reviewed the three DepSecDef memos cited above and outlined the following functions for his office:

In summary then, the Deputy Director Test & Evaluation (DDT&E) (with the assistance of his staff) is to accomplish the following:

1. Have across-the-board responsibilities for test and evaluation in the Department of Defense. Review test and evaluation policies and procedures of the DOD and the Military Departments and recommend changes as appropriate.

2. Monitor closely test and evaluation programs conducted by the Services for DSARC programs and such other programs as he believes necessary throughout the entire testing cycle. Report to the DSARC and directly to DepSecDef at DSARC Milestones I and II his assessment as to the adequacy of the list of critical issues and problems to be attacked by test and evaluation and the schedule of test milestones, and report at Milestone III to the DSARC and to the DepSecDef his independent recommendation.

3. Insure timely OT&E to meet the intent of DepSecDef's direction described in 2a above.

4. Request Service test plans and test results as may be required to accomplish (1), (2), and (3) above as early as such plans are developed by the Services and needed by DDT&E.

5. Initiate and coordinate appropriate joint testing.

6. Oversee the evaluation of foreign systems for possible DOD use.

7. Administer for OSD its responsibility for the national and major Service ranges.

8. Carry out such other T&E related activities as the SecDef, DepSecDef, DDR&E, or other DSARC member may direct.

6. <u>More from The Deputy</u>

LTGEN A. D. Starbird, the Deputy Director Defense Research and Engineering for Test and Evaluation, in an address to the 7th Naval Aviation Test and Evaluation Conference at NATC Patuxent River, Md., on 24 August 1971 commented on the evolution of test and evaluation concepts and emerging policies as follows:

a. As we all know the Military Departments and the DOD have increasingly come into criticism in almost all phases of their activities. Unfortunately, test and evaluation has not escaped. In fact, on many occasions it has come in for severe criticism. Each time a system in rather advanced stage of acquisition runs into trouble, there are critics who center on inadequate test and evaluation as a major culprit.

b. It is interesting to me that the criticism of test and evaluation has come from many different quarters. On occasion, the press and the public have been critical. Congess in general has a sincere interest in seeing that we do adequate test and evaluation and their criticisms have been fairly frequent. The GAO has been critical, much more so recently than in earlier years. The President's Scientific Advisory Committee was asked to study out T&E and they emerged with certain criticisms. Many of you are probably familiar with the fact that the President's Blue Ribbon Defense Panel, which reported about a year ago, was quite critical of test and evaluation and particularly the quality of the operational test and evaluation accomplished by the Departments.

c. Some of the critics have called for rather radical changes in how we do our T&E business. The Blue Ribbon Defense Panel, for example, recommended: appointment of an Assistant Secretary of Defense for Test and Evaluation to have a strong hand in approving Service test plans; and an OSD-level Test and Evaluation Agency to carry out the more critical DOD program tests.

We all realize that many of the criticisms leveled at our T&E are just not justified. We in the DOD have done in the past, and are doing now, much excellent testing. The results in the effectiveness of many of our complex systems show that our test and evaluation have been good. We devote a tremendous amount of effort of the best people and at high cost to test and evaluation. On balance, I believe that the Services are on the par with any other large industry, and perhaps ahead of most.

But we have had faults and some of those persist. For these we are rightfully criticized. The faults in general fall in two categories.

First is the availability of test results. Frequently the testing and its evaluation are completed long after critical decisions and major expenditure of funds have been made. We are well into production before we realize from tests that we will not reach the reliability goals specified. We are well into deployment on occasion before we know that we cannot maintain adequately. The first valid criticism then is that much of our testing is not timely.

Second, our key testing to determine operational effectiveness and suitability is often not accomplished until we are irrevocably committed at large dollar cost to some particular design. We do not accomplish early enough adequate operational test and evaluation. There are many definitions of operational testing but I think we all know what it means. It is testing of a product reasonably representative of the final design, by operational units, in the type of environment the system will encounter when deployed, so as to establish its military worth and operational suitability. Included in that matter of operational suitability is whether its reliability requirements can be met and without undue maintenance.

Secretary Laird and Secretary Packard have both been extremely interested in our test and evaluation from the time they took office with the Department of Defense. I remember two long sessions within the first week after they were sworn in when they met during most of one evening on a system for which I then had responsibility. Both asked many, many questions dealing with test organizations, test results and test plans. Both for many months have discussed with the Service Secretaries and the Military Chiefs what steps were necessary to accomplish improvements. Beginning early this calendar year, they issued a series of three instructions indicating what changes they desired to be made. The latest is the instruction by Secretary Packard of 3 August to which I earlier referred. Reading these collectively you can see that their objectives are really four in number.

First, and I believe this their primary objective, they desire to improve rather than revolutionize our test and evaluation approach. They want to build on the good that exists rather than to start again from scratch.

They want to avoid "adding testing just for testing's sake." They insist that everyone know the objective of their testing before embarking on their test program.

They insist that the testing be timely, -- that it be adequate and scheduled for evaluation in time to contribute to the major decisions they must make. (I should point out that, for all important systems being acquired by the Services, they must approve moving a program from concept definition into advanced development, the subsequent movement into engineering development, and the third and more important decision to move into production.)

They insist too that the testing be realistic, that it be in sufficient detail and adequately evaluated to give realistic answers.

7. T&E and The Congress

Congress, recognizing the importance of test and evaluation in the procurement of weapons systems, enacted in Public Law 92-156 of November 17, 1971 a Section 506. A partial quote of that Section as applies to test and evaluation follows:

"Sec. 506. (a) Beginning with the calendar year 1972, the Secretary of Defense shall submit to the Congress each calendar year, at the same time the President submits the Budget . . . a written report regarding development and procurement schedules for each weapon system for which fund authorization is required . . . Beginning with the calendar year 1973, there shall be included in the report data on operational testing and evaluation for each such weapon system for which funds for procurement are requested (other than funds requested only for the procurement of units for operational testing and evaluation and/or long lead-time items) . . .

"(b) A supplemental report shall be submitted to the Congress by the Secretary of Defense not less than thirty nor more than sixty days before the awarding of any contract or the exercising of any option in a contract for the procurement of any such weapon

system (other than procurement of units for operational testing and evaluation and/or long lead-time items) ...

"(c) Any report required ... shall include detailed and summarized information with respect to each weapon system covered by such report, and shall specifically include, but shall not be limited to -- ...

"(3) ... the results of all operational testing and evaluation up to the time of the submission of the report, or, if operational testing and evaluation has not been conducted, a statement of the reasons therefor and the results of such other testing and evaluation as has been conducted."

D. IMPLEMENTATION DIRECTIVES AND INSTRUCTIONS

1. SECNAVINST 5000.1

To implement DODD 5000.1, the Navy issued SECNAVINST 5000.1 and other flowdown directives which will be discussed later. Paragraph 6e of the basic instruction assigns COMOPTEVFOR (Commander, Operational Test and Evaluation Force) responsibility as an independent test agency for weapon system acquisition required T&E. It is interesting to note that enclosure (2) of the basic instruction canceled 28 previous instructions, of which three had T&E in their titles.

Enclosure (3) to the basic instruction entitled "Policy, Relationships and Responsibilities" contains the real meat of system acquisition direction within the Navy. For designated projects (Major Defense Systems such as those in Selected Acquisition Reports), the mode of operation for Project Managers is prescribed. The Project

Manager is directed to establish coordination with the DRDT&E (Director, Research, Development Test and Evaluation) to ensure adequate operational test planning and operational test and evaluation accomplishment. Section II of enclosure (3) indicates that test and evaluation is to be a consideration in RDT&E conceptual effort, full-scale development, and preproduction. Paragraph II.C.2.b. states that programs will not normally be proposed to the DSARC for SECDEF approval for production prior to completion of requisite operational test and evaluation. Deviations to prescribed T&E can be made only by or with the concurrence of the SECNAV.

Section II, "Program Considerations," in paragraph D further spells out T&E policy as follows:

1. The wide variety of naval weapons dictates varying approaches to the conduct of test and evaluation; such effort shall be tailored to the needs and characterizations of each individual acquisition -- prime consideration being given to adequate operationally oriented testing. Normally, the following general sequence of events should prevail; (1) laboratory/contractor preliminary test and evaluation of breadboard of demonstration hardware during the conceptual effort, (2) contractor/development activity test and evaluation of subsystems and/or full-scale demonstrator hardware during full-scale development, (3) technical test and evaluation conducted by the contractor with Navy/Marine Corps participation during pre-production/production, (4) IOT&E (Initial Operational Test and Evaluation) by or with the active participation of Navy operational forces prior to the major production decision, (5) Navy/Marine Corps OPEVAL (Operational Test and Evaluation) prior to approval for service use and inventory acceptance (except for ships), (6) Navy/Marine Corps follow-on test and evaluation, and (7) the conduct of tests and evaluations by the Board of Inspection and Survey (BIS) and recommendation to the Chief of Naval Operations for service acceptability. Test and evaluation effort shall be effectively correlated with previously outlined requirements concerning approval of material for service use.

Specifically, the procedural aspects of requirements determination, research and development, manufacture of service test model(s), technical evaluation, initial operational test and evaluation, full operational evaluation, and approval for service use shall be correlated.

2. New acquisition includes conversions, major modifications and modernizations. Adequate test and evaluation of these is also required ......

3. For new acquisitions ... the principles of early operational test and evaluation before production decision, participation by the Marine Corps or COMOPTEVFOR shall apply. The purpose of IOT&E and other tests is to provide assessments and recommendations by an activity independent from the development activity concerning the future operational suitability of systems under development.

4. The objective of the overall operational test and evaluation effort for any program is to aid in providing, at major decision points in the development and acquisition process, the best information possible at that point in time as to: the military utility of the prospective system; its expected operational effectiveness, operational suitability (including reliability, maintainability, simplicity, logistic, and training requirements); need for modifications; and the organization, doctrine and tactics for system deployment ...

2. <u>Congressional Concern</u>

Concurrent with the issuance of DODD 5000.1 and the Navy's implementing instruction SECNAV 5000.1, there was increasing Congressional concern over testing of major acquisitions. Because of the major problems encountered with weapons programs as a result of inadequate testing, Congressional committees increasingly qualified the authorization of resources assigned to programs until comprehensive testing had been completed. Following are some examples from the fiscal year 1971 and 1972 authorizing appropriations to illustrate this increased interest by the Congress. The restraints applied most

often occur during requests by the services to place a major weapon in full-scale production.

In Public Law 91-441, dated October 7, 1970, the Congress stated that:

> Of the total amount authorized to be appropriated by this Act for the procurement of the F-111 aircraft, $283,000,000, of such amount may not be obligated or expended for the procurement of such aircraft until and unless the Secretary of Defense has (1) determined that the F-111 aircraft has been subjected to and successfully completed a comprehensive structural integrity test program . . .

In House Report 92-232 on authorization appropriations for fiscal year 1972, SRAM and MAVERICK were discussed.

> The AGM-69A SRAM is an air launched air-to-surface missile for planned use on the B-52G/H and FB-111 aircraft. The SRAM missile is equipped with a nuclear warhead designed to attack targets defended by sophisticated defense systems. The fiscal year 1972 program provides for proceeding to full-scale production considering completion of testing.

> MAVERICK is an air-to-surface Air Force missile, electro-optically guided for use against small hard targets such as tanks and bunkers. Last year the Congress, on the recommendation of the Committee on Armed Services, denied requested procurement funds for MAVERICK and directed that the program be continued in research and development to avoid concurrency and to allow more reliable development and test results prior to initiating procurement.

3. <u>T&E and the GAO</u>

At the request of the Honorable Carl Albert, Speaker of the House of Representatives, the General Accounting Office (GAO) made a review of the importance of testing and evaluation by the Department of Defense in the acquisition process for major weapon systems.[2]

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[2] <u>The Importance of Testing and Evaluation in the Acquisition Process for Major Weapons Systems,</u> The Comptroller General of the United States, 7 August 1972.

Their report indicates that the benefit of testing is accomplished through properly assessing risks and delivering test results to the decision-maker at key points in the acquisition cycle when final decisions must be made. Testing at decisive stages of development was found to show where problems exist and to help military managers make sound decisions affecting future production and purchase of weapons than would otherwise be possible.

The GAO reviewed 13 weapon systems with estimated total costs of more than $46 billion. They included such weapons as the Army's improved HAWK missile, the Navy's DE-1052 (destroyer escort), and the Air Force's F-15 aircraft. On the basis of its observations of the pattern of testing performance, the GAO concluded that:

--Practices used to establish objectives for testing generally were adequate.

--Most weapon systems did not have adequate plans for conducting tests.

--Testing and evaluation for most weapon systems was not accomplished in a timely manner.

--Most test reports were adequate, but their value was diminished due to inadequate test planning and actual testing. Some reporting improvements could be made.

--Complete and valid test and evaluation data was not available prior to those times in the acquisition cycle when decisions had to be made.

Based on DOD's listing of five phases in the acquisition process of weapon systems (1 concept formulation, 2 validation and

ratification, 3 development, 4 production, and 5 deployment) the GAO formulated a model (Appendix A) to depict the role of testing in the acquisition cycle. The purpose of GAO's model was to reinforce and emphasize certain ideal concepts of testing and evaluation in the acquisition process, as follows:

--Testing and evaluation is an important ingredient throughout the acquisition process.

--The sequential nature of engineering; acceptance; and, to some degree, operational suitability testing and evaluation.

--The responsibility for the success of testing and evaluation throughout the acquisition process lies with the developer, the user, and the contractor in different degrees and at different times.

--To provide a means for DOD and weapon systems program managers to evaluate the testing and evaluation process in their respective programs.

4. Laird's Viewpoint

In his final report to the House Armed Service Committee on January 8, 1973, Secretary Melvin Laird indicated that with the help of David Packard, many changes had been made in the weapons system acquisition process but that it would take some years before the improvements would be fully validated. He indicated that bankrupt practices such as total package procurement and an indiscriminate use of concurrency between development and production had been eliminated. His substitutes included "test before you fly" and "fly before you buy" procedures, and the widespread use of contract milestones and prototyping.

5. DODD 5000.3

In January 1973, the several earlier T&E memoranda were superseded by DOD Directive 5000.3 entitled "Test and Evaluation." It was in somewhat more detail and tightened to a degree the earlier memoranda instructions:

--It stated certain principles that should apply to all acquisition programs. T&E would start as early as possible and be conducted in phases so as to eliminate risks early. Acquisition schedules must be keyed to accomplishing T&E milestones before major added resource commitments were made. Prior to contracting for major production, there would be completed: sufficient development testing (DT&E) to insure that all design problems were identified and solutions were in hand; and sufficient operational testing (OT&E) to provide a valid estimate of operational effectiveness and suitability.

--In each Service, OT&E would be the responsibility of a field agency independent of the developing command. Typical military operating/maintaining personnel and units were to carry out the test, -- not highly trained development technicians. Such operational testing was to be conducted in a simulated operational environment where the stresses of real combat operations (such as fatigue and countermeasures) were applied to the degree possible.

--Operational tests preferably were to be separate from development tests. However, an early phase of operational testing could be

combined with a development test providing the combined test was participated in and accepted by both the developer and the independent operational test agency as satisfying their individual requirements. Pilot production items were to be used wherever possible for the development and operational testing completed before commitment to major production. However, final prototypes could be employed where these prototypes were truly like the expected production items.

--For T&E of ships of a major class it was recognized that because of the long design, engineering, and construction period, completion of T&E prior to the decision to proceed with follow ships would not in all likelihood be possible. "In lieu thereof, successive phases of DT&E and OT&E will be accomplished as early as practicable at test installations ... to minimize the need for modification to follow ships." Use of prototypes to achieve T&E prior to the first major production decision on follow ships is advocated.

--The directive included an important new provision with respect to waiving satisfactory completion of required T&E. For each major acquisition program, the describing Development Concept Paper (DCP) sets forth such required T&E and only the Secretary of Defense can waive its accomplishment.

6. OPNAVINST 3660.8

OPNAV INSTRUCTION 3660.8 of 22 January 1973 established guidance and policy for T&E of Navy systems and equipments in

accordance with the requirements of SECNAVINST 5000.1 and DODD 5000.3. The instruction reemphasizes that Navy weapon system acquisitions shall provide for T&E programs to (1) permit a clear determination of service acceptability and suitability by competent authority; (2) support the development activities in evolving a design which meets specifications and service requirements; (3) support the Secretary of Defense review and decision process.

It recognized that conventional ship programs may be large, complex and prolonged evolutions. Consequently, development T&E required on a specified subsystem or groups of subsystems may be conducted on board other class ships or at land-based test sites. In the case of a new hull or propulsion designs prototypes, or land-based test sites, construction is normally undertaken to verify laboratory DT&E.

While previous instructions and directives addressed T&E in general terms, 3960.8 defines T&E specifically and discusses T&E of weapons systems in the following areas: developmental testing, operational testing, and acceptance trials. The following pertinent definitions are made:

TEST: Any program or procedure which is designed to obtain, verify, or provide data for the evaluation of; research and development; progress in accomplishing development objectives; or performance and operational capability of system, subsystems, components, and equipment items.

DEVELOPMENTAL TEST AND EVALUATION (DT&E): Test and evaluation performed by or for the developing agency which emphasizes the technological and engineering aspects of the system, subsystem, or equipment items. Normally carried out under strictly controlled conditions.

OPERATIONAL TEST AND EVALUATION (OT&E): Tests and evaluations participated in or performed by operational personnel focusing on operational effectiveness and suitability (including reliability, compatibility, interoperability, maintainability, and supportability). It also includes the development of optimum operational tactics for systems and equipment being developed for service use.

OT&E is further broken down into the following areas:

INITIAL OPERATIONAL TEST AND EVALUATION (IOT&E): That T&E accomplished prior to the DSARC Milestone III or comparable CNO or CHNAVMAT first major production decision point to permit assessment of the operational effectiveness and suitability of a weapon system.

FOLLOW-ON OPERATIONAL TEST AND EVALUATION (FOT&E): The continuing operational test and evaluation of a weapon system conducted in an operational environment by operational personnel using production systems for the purpose of verifying system performance; validating correction of deficiencies previously identified; and refining tactical employment doctrine and requirements for personnel and training. FOT&E may be initiated using pilot or pre-production systems which most closely resemble the production units until the latter items are available.

A comprehensive set of definitions of terms and phrases commonly used in T&E, checklists for T&E in support of milestones I through III of the DSARC process, and a diagram of the acquisition process are provided as enclosures. T&E responsibilities and relationships which have evolved are also discussed which will be the subject of the following section of this thesis.

7. NAVMAT NOTICE 3960

NAVMAT NOTICE 3960 of 1 February 1973, "Test and Evaluation Policy for Major Surface Combatant Ships Project," assigned the Major Surface Combatant Ships Project Manager, PM 18, responsibility for T&E effort within the Naval Material Command relating to major surface combatant ships. The ship classes include DLGN 36, DLGN 38, DG, DD 963, LHA, PF, SCS, and CVAN 68.

The Notice recognized that in the past, ship acquisition T&E philosophy had been tailored to the needs and production approach of each individual ship program. In light of recent DOD policy for major weapon acquisitions establishing more standard criteria for the approval of programs (DCP/DSARC), a need for adoption of more uniform T&E procedures was recognized. Guidelines for test planning are provided in conjunction with the PM-18 functional organization. Test processes and relationships in test design, development and execution are provided.

The requirement for a Test and Evaluation Master Plan (TEMP) as initial policy in T&E for major surface-combatant acquisition programs was laid on. The TEMP is to be keyed to acquisition milestones and should cover all T&E requirements through the production phase including follow-on operational testing. It should include development of the maintenance and ship-overhaul baseline test program for the equipment and system-level Planned Maintenance System (PMS).

It directed that test planning should be total-ship oriented to assure adequate coverage of all work breakdown structure groups and to assure that all systems are properly installed and completely operable, before a ship is presented for Board of Inspection and Survey (BIS) trials. Additionally, a Total Ship Test Director (TSTD) responsible for planning and execution of the T&E program is required for each program.

8. NAVMATINST 3960.6

NAVMAT INSTRUCTION 3960.6 of 24 August 1973, "Planning and Implementation of Tests and Evaluations of New Weapon Systems," provides further guidance and direction for preparing the TEMP. Under this instruction, the TEMP is considered to be a management document and serves as a foundation for the more detailed DT&E and IOT&E plans. Its basic elements are objectives, issues, responsibilities, interfaces and schedules. It should be viewed as a planning document rather than a control document.

9. NAVMATINST 3960.XX

NAVMATINST 3960.XX, a draft instruction of 21 December 1973, is presently under review within NAVMAT. The instruction, "Test and Evaluation of Ship Acquisition," has been prepared to formalize NAVMAT policies and procedures for ship acquisition T&E in order not only to respond to DOD and OPNAV requirements but also to provide coordination and standardized approach to the development of test requirements and the supporting test documentation.

The Ship Acquisition Project Manager (SHAPM) is assigned the responsibility for developing from appropriate OPNAV design requirements and his own risk analyses the test requirements necessary to reduce ship acquisition risks.

Enclosure (1) to this instruction, "Management Plan for Total Ship Test Program for Ship Acquisition," prescribes the basic management structure and procedures to be followed for developing test documentation that will satisfy the objectives of ship acquisition T&E and will also support the total ship test program (TSTP) for active fleet ships. This enclosure is a comprehensive document that attempts to bring together within a single cover T&E organization and responsibilities, test documentation requirements, and development of a ship construction integrated test package. It is against this background that the proposed and on-going T&E efforts of the Patrol Frigate project will be compared and analyzed in this thesis.

IV. SOME PROTOTYPING CONSIDERATIONS

A. GENERAL

Navy prototyping is still evolving in the fly-before-buy era. It is based primarily on past experience with prototyping and Total Package Procurement. It is also influenced by the procedural and standardization guidance received on a continuing basis from the DOD as developed in the previous chapter. The literature concerning weapon system acquisition, DOD and Navy Instruction, and various memoranda are filled with positive statements concerning the use and advantages of prototypes. These statements take the form of:

David Packard, "We want to put more reliance on hardware and less on paper studies in advanced development."

Dr. John S. Foster, Jr., "We desire to emphasize the use of prototypes."

Barry J. Shillito, "Under prototype development, we will evaluate hardware rather than paper promises in choosing a contractor."

CAPT E. J. Otth, SHAPM for the Patrol Frigate Acquisition, "We expect to use a land-based test site for the combat system as well as the propulsion system to enable us to verify integration and performance of these systems in an environment more controlled and less costly than aboard ship."

Early in 1974, discussions with Mr. Matthew T. Reynolds, NAVMAT's point of contact in PM 18 for all T&E matters relating to major surface ships, indicated that trends in prototyping of combat systems in new ship-class acquisitions had reached the point where prototyping was essentially mandatory. At least at this point of time in acquisition philosophy, prototyping is an "in" concept. Therefore, what prototyping is and what expected gains and costs are incurred in its use are of considerable interest.

Conventional wisdom has it that a prototype is a redundant and often costly adjunct to the design and development process. This thesis considers the proposition that under given circumstances the most effective way of resolving some of the uncertainties of combat system development is by building and testing a prototype system at a land-based test site. Underlying the discussion is the premise that no single specified pattern of behavior can adequately provide for all of the contingencies that will arise in the course of combat system development. Additionally, the premise that cost and the long lead and production times involved in ship construction do not permit the prototyping of entire ships prior to production decision points is accepted without argument or further comment. The combat system portion of the total ship is broken out as a prime candidate for prototyping in contrast to the relatively fixed containment system which houses and supports the combat system.

B. CONCEPTS

To many people, the word "prototype" evokes images of the 1930's and the 1940's, suggesting the angularity of a biplane, the quaintness of goggles, and the hum of electronic equipment patched together with tape and spliced wires. But what is being discussed here is something quite different; a vehicle for lessening technological uncertainty. It might be more appropriate to call that vehicle a definition-phase test combat system or perhaps a demonstrator combat system, rather than a combat-system land-based test site, if only to deter prejudgement concerning the utility of using a land system to emulate shipboard systems. But prudence suggests merely defining the term as it is to be used here and leaving language reform for another occasion.

There are many possible themes in any consideration of the use of prototypes in development. The hypothesis from which this thesis reasons is that: (1) establishing the detailed configuration of a new combat system requires many decisions, each difficult, and each dependent on the resolution -- or avoidance -- of uncertainty; (2) the elemental substance of T&E is error and uncertainty, and delay in the detection and correction of error or oversight is a principal cause of inefficiency or ineffectiveness of development; (3) the early resolution of uncertainties in technology, objectives, schedules, and costs is vital, there are various ways of resolving such uncertainties, and a technique of resolution most appropriate to the problem at hand should

be chosen; and (4) in some circumstances, which can be defined, the most desirable way of resolving technological uncertainty in ship acquisition programs may be to build and test a prototype combat system.

There are many definitions of "prototype" and little profit in laying them end to end for scrutiny. Basically this thesis will consider a prototype combat system to be a hardware-software combination approximating, in full scale, the main features of a prospective operational combat system. Land-based tests must yield information that will permit the timely identification and resolution of technological uncertainties and ultimately support a sound decision about the procurement of production systems. Additionally, the prototype may be used to suggest ways the design, structure and development of the combat system can best accommodate the shipbuilder's requirements for detailing the design of cabling and ducting, assess maintenance requirements, and be useful throughout the life-cycle of the production system as a test and configuration bed. Owing to the nature of a prototype, it is not very likely that all prospective subsystems will be available as early as selected hardware items, and some simulations may have to be used in place of other items.

C. WHEN TO PROTOTYPE

The following figure (p. 57) presents some concepts for consideration in prototyping decisions. Seen thus, a prototype is a device to

PROTOTYPING

TYPES OF DECISIONS IN WHICH PROTOTYPING MAY BE CONSIDERED	VARIABLES INFLUENCING DECISION (YES/NO)	PRINCIPLES FOR CONDUCTING PROTOTYPING
1. ADVISABILITY OF PRODUCING	1. COST	1. EXPECT CHANGE
2. TRADEOFFS BETWEEN SIMILAR SYSTEMS	2. TIME	2. CONTROLLED INVESTMENT
3. WHICH SYSTEM TO BUILD	3. QUANTITY	3. DEFINING AND LIMITING UNCERTAINTY:
4. TECHNOLOGICAL FEASIBILITY	4. TYPE OF CONTRACT	a. Strategic
		b. Technological
	5. DESIGN MATURITY	c. Previously unrecognized
	6. POLITICAL PRESSURES	4. FLEXIBILITY

moderate some of the uncertainty that characterizes the decision process. Because a prototype is a full scale, semi-operable representation of what is intended to be in time an operational combat system, decisions buttressed by experience with prototypes tend to be founded on less tenuous technological grounds than those based on abstract analysis and derived from assumptions. Reliance on prototypes appears to be advantageous for four general classes of development decision. (1) When there is uncertainty about the advisability of producing a given combat system, testing a prototype will provide reliable information about the attributes of the combat system and will reduce the quantity and importance of misgivings. (2) When there is uncertainty about which of two similar hardware/software combinations to produce, testing subsystems built by different contractors will ease the decision. In the same vein, if cost overruns or technical inadequacy of subsystems causes fall back to other equipment, a prototype lends a suitable means for incorporating these emerging configuration changes. (3) When there is uncertainty about which combat system to build, testing prototypes, liberally supported with realistic simulations, will provide hard information on which a choice can be based. (4) When there is uncertainty about the technological feasibility of a configuration, prototype testing can assist in resolving the main issues.

The matter of whether a prototype program is inherently more or less costly than a program that bypasses the prototype option can be

treated, for the moment, as incidental. It is apparent that cost and schedule estimates derived in part from experience with prototype combat systems will tend to be somewhat less uncertain than estimates based solely on analytical predictions of development progress. From the fact that specific uncertainties of technology, configuration, and probable mission responsiveness will be moderated by the very existence of a prototype, it may be adduced that a prototype strategy can be used as a means of preserving a production option -- putting off a final decision until requirements of technology are better understood while concurrently working toward that understanding.

There is no inherent reason why "Total Package Procurement," should not include a prototype phase if the "total package" decision specified quantities and schedules but made configuration definition a function of an evaluation process following prototype testing. Or, for that matter, "total package" could be interpreted to mean all development and production activity following a definition phase that provided for building and testing prototypes. Within current thinking however, a prototype provides a vehicle to "test before flying," and "flying before buying."

A prototype should be built in the expectation of change, and the expectation of change is its only substantial justification. The objective of building a prototype is to discover what changes are necessary -- what decisions must be made -- before a design is committed to

production, or to discover if any number of changes will end in a desirable production combat system. Such a characterization does not invalidate the use of prototypes to aid in resolving mission uncertainty or to aid in equipment/contractor selection or to contribute to a decision on which (rather than what) to produce, but it emphasizes the contribution of a prototype to the diminution of uncertainty, whatever the nature of that uncertainty.

From such assumptions arise two principles for the conduct of programs based on the use of prototypes: (1) controlled investment -- that is, obtaining an informational return at an expenditure commensurate with the worth of the information, and (2) defining and limiting uncertainty; which is to say, having the principal features of a combat system reasonably well defined before undertaking construction. Although planners may squirm at the thought, there is no obvious reason for specifying the detailed operational assignment of a combat system while a prototype is being built and tested; the question of whether it should have one or two digital computers cannot be put off in the same way. Flexibility however, must be built into the system to enable modification to reasonably expected equipment and/or threats in the planning future.

A prototype combat system should not be expected to resolve uncertainties that are peripheral to the main purpose of building it, nor should peripheral uncertainties be permitted to dominate a

prototype program. Technical problems that can readily be identified and solved by analysis and discrete off-site testing should not be left to a prototype test inquiry. Nor should very great technical uncertainties be left for resolution by means of a prototype combat system. Basic technological feasibility is not an issue that can be satisfactorily resolved at the prototype level; feasibility demonstrations cannot be put off until operational requirements begin to hinge on their success. A prototype is not a specific vehicle for uncovering "unks-unks" nor for resolving basic policy differences between contributing factions.

When the time or urgency of a requirement is in doubt and it is possible to select between two courses, one of study and proposal and the other of build and test, the relative advantages of the two should be very carefully evaluated. If a prototype can be built for not much more than the cost of conducting an extended analysis, a prototype seems preferable because it can be expected to produce more reliable information than a study. If such information becomes available in advance of a production decision, the lead time between production decision and availability of operational combat systems will be lessened by the amount of "learning time" that would otherwise follow a decision to produce a combat system only defined on paper. Indeed, the performance of the prototype in land-based trials may not only enhance the validity of acquisition decisions, it may also solidify them, as a decision based on an existing prototype will generally contain less

residual uncertainty than one based solely on analysis of engineering expectations.

In essence, then, the construction of prototype land-based combat systems can provide a hedge against requirements (strategic) uncertainty. It does so by permitting a more certain resolution of technological uncertainties than can design studies, no matter how elegant they are. The central fact is that under almost any conceivable circumstances the transition from design proposal to first lot of production articles brings on change, and change introduces new uncertainties. Some are uncertainties that can be resolved with no particular difficulty while production continues. The function of a prototype is to permit the early identification of previously unrecognized problems and the resolution of recognized uncertainties that might, if they went undetected, precipitate major changes in the performance, cost, or availability of specific weapon systems.

Adhering to the principles described above would be difficult in any circumstance. It is very difficult today. The pressures for early commitment to production are enormous. The customer, in this instance, the Navy, is conditioned by the military environment to be less interested in the comprehensive resolution of uncertainty than in the early delivery of operational ships and combat systems. There is a natural tendency to assume that all problems will be little ones. In this situation the producer has very little motivation for investing

time and money in a prototype. Profits come from production. Firms are not paid very well for military development. Contractors would rather build what are incorrectly called "production prototypes" than "development prototypes," because a "production prototype" implies a strong commitment to production while a "development prototype" represents a proposal of which the faults, if any, are all too evident. Here again, when a "production prototype" is built the producer will be optimistic about the possibility of solving all problems early and, as has been observed, the customer is anxious to believe such reassurances.

Some critics and defense-industry experts recently (January 1974) have stated that a prototype, as a preproduction step, tends to blur the line between development and full production, enabling the Services to move systems into production a little bit at a time. In another vein, others argue that a preproduction prototype gives congressional critics more time to attack. The presumably higher price tag is an argument against building the ship/combat system which in turn is dysfunctional to the service who is trying to abide by directives and test before buy concepts.

D. DOD, THE NAVY AND PROTOTYPING

The DOD's current philosophy is that the use of prototypes must be increased in all development efforts to reduce costs and resolve

uncertainties prior to major production commitments. DOD has broken prototypes into three categories as follows:

1. Experimental -- to demonstrate technological feasibility.

2. Developmental -- to gain sufficient confidence before comitting a system to full-scale development.

3. Production -- to prove out the system, tools and methods prior to quantity production.

The DOD normally recognizes three approaches to prototyping, which are in most cases applied to experimental and developmental prototypes. They are as follows:

1. Sole/single source -- prototypes developed and fabricated by a single developer.

2. Competitive -- prototypes involving the same technology, developed and fabricated by two or more developers.

3. Complementary -- prototypes involving different technologies, developed and fabricated by two or more developers in response to the same basic requirement.

The breakdown and extent of prototyping per se is broken out as follows:

1. Component -- part of an assembly of parts to perform a function.

2. Subsystem -- a major functional assembly of a system.

3. Hybrid -- a system of equipment based upon an alteration or change to an existing system or equipment.

4. "Bare-bones" model -- a system or equipment containing only its minimum essential elements.

5. Complete system -- a combination of subsystems that makes up the ultimate system or equipment.

As should be seen from the above, prototyping can take many forms and seek many ends. To achieve a completely successful and highly efficient set of prototype terminology is one of the important goals which the Navy feels must be achieved, if it is to be successful in implementing recent prototyping policies. The figure below depicts what appears to be the direction the Navy is going in its efforts to comply with guidance from DOD on prototyping and defense system acquisition in achieving a set (or body) or prototype terminology which can be utilized through the spectrum of Navy acquisition.

TERMINOLOGIES			
Prototype Terminology	Weapon Subsystems	Ships-conventional hull design	Ships-new hull design
Experimental Prototypes	Bread board Models	not applicable	Research Vehicles
Development Prototypes	Advanced development models/ prototypes	-land-based testing -test bed ships	Test craft
Production Prototypes	Pilot production models/prototypes	Lead ship	Lead ship

A word of caution is in order when applying any so-called guide such as that in the previous figure. The purpose of such a guide is to enhance understanding and communication, not to impose a rigid set of rules which will do more harm than good. The best example available is probably that of shipbuilding, whereby a period of several years will be required for transition from present methods of shipbuilding to the sequential "fly-before-buy" approach, even for ships in the 5,000-ton category. For larger ships such as carriers, the Navy must and will look for innovative ways to comply with the spirit of new prototype, test, evaluation and acquisition policies, but an idealized sequential program plan will not be attainable in all cases.

Likewise, the figure should not be interpreted to mean that each and every step must be accomplished in each and every program. As a general rule, when determining whether certain steps may be omitted or not, development prototypes should not be required when the technology has been "hardware" demonstrated in some other program or by experimental prototypes. Neither should production prototypes be required when engineering change proposals of a minor nature can be made to "off the shelf" or "in production" defense systems of another Service.

F. SUMMARY

The central thesis of this chapter is that in certain circumstances it is sensible to build and test a prototype of a combat system before

finally deciding to produce it in quantity. Such circumstances can occur if the technological risks inherent in the design are substantial and cannot be reduced to manageable proportions by analysis alone. The difficulty of deciding when to adopt a prototype strategy arises from the necessity of deciding a priori how substantial are the technological, mission assignment, or source-selection risks.

The circumstances under which the construction of a prototype combat system becomes a desirable element of the total development program include:

1. A program sufficiently well defined to permit developers to undertake the resolution of specific technological uncertainties that cannot realistically be expected to succumb to alternative techniques of uncertainty resolution (such as analysis and simulations) or that can be alternatively resolved only at greater cost than by the prototype route. (Build a complete ship only to discover that the combat system doesn't operate properly.)

2. When developers understand that the real purpose of a prototype combat system is to identify necessary design changes quickly and accurately, and that one outcome of a prototype program can be a decision not to proceed to production. The object of a prototype is to permit a prompt and economical decision in such matters.

The real payoff which the Navy expects to achieve in prototyping programs can only be realized if thorough cost analysis and test and evaluation is conducted, reported and utilized by source selection

boards, project managers, contract negotiators, and high-level decision makers at every sequential step in the defense system acquisition process. The remainder of this thesis explores the efforts of the Patrol Frigate program to accomplish these objectives.

V. THE PATROL FRIGATE'S TEST AND EVALUATION PROGRAM

A. GENERAL

The Patrol Frigate Ship Acquisition Program was chosen as an example of ongoing T&E and prototyping efforts because of the availability of information, the cooperation extended by Project Office personnel, and several unique features of the acquisition program itself which lend application to subsequent ship procurement programs. The PF is also the first major ship acquisition program to come under the auspices of DODI 5000.1, DODI 5000.3, and additional T&E guidelines developed in Chapter 3.

B. PATROL FRIGATE SHIP HIGHLIGHTS

1. Objective of the PF Program

The objective of the PF program is to acquire for the late 1970's-1980's timescale a class of ships capable of ensuring our use of essential sea lines of communications. It is intended that these ships will provide, at least cost, the necessary improvement in the Navy's surface combatant capability to:

- Defend non-carrier forces against airborne forces
- Conduct ASW operations

These operations will be conducted in conjunction with other sea control forces.

2. Ship and Program Constraints

The PF is an austere escort ship designed toward the major program goals initially imposed by CNO, as follows:

- Average follow ship cost (without escalation) not exceeding $45.7 million (FY 73 dollars).

- Full load displacement not exceeding 3400 tons

- Total personnel accommodations not exceeding 185.

In order to meet the cost constraints, weapons and sensors requiring research and development have not been included in the PF design, at least in theory. Ensuring approval for service use of major individual equipments and systems has been made the responsibility of the Systems Commanders, NAVSHIPS, NAVORD, etc.

It is intended that the PF will operate in conjunction with other sea control forces and not as an independent unit. Hence the PF has been designed to supplement the capability of other ships rather than operate in a stand-alone capacity.

3. Mission Requirements

To ensure our use of essential sea lines of communication against the contemporary and postulated threats along with planned and existing escort forces, Development Concept Paper #97 of 3 April 1973 requires the PF to be able to:

- Provide self-defense and operate as part of an ASW screen defending the escorted force or operate on picket station in support of the escorted forces.

- Operate in conjunction with other escorts to provide area and close-in AAW defense of the escorted force and self-defense against aircraft and airborne anti-shipping missiles.

- Provide for defense of the escorted force and own ship against hostile surface ships to over-the-horizon ranges.

- Operate in conjunction with other forces in open ocean ASW operations and subsurface surveillance.

- Supplement area AAW forces in the detection and engagement of airborne threats.

- Enforce blockades and operate offensively in conjunction with other forces against mercantile shipping and naval forces.

- Provide for SAR, surveillance and evacuation operations and establish a naval presence.

- The PF is not intended to serve as a carrier force escort or in high-threat areas.

4. PF Combat System Components

Systems selected for the PF consist of the following:

WEAPON

-Standard Missile (Surface-to-air)

-Harpoon Missile (Surface-to-surface)

-76mm Oto Melara Gun

-Space and weight for Close In Weapons System (CIWS)

-Mk 46 Torpedo

LAUNCHER

-Mk 13 Guided Missile Launcher (Fires Harpoon or Standard Missiles)

-Mk 32 Torpedo Tubes

FIRE CONTROL SYSTEM

-Mk 92 (STIR) Two Channel System

SENSOR

-SPS-49 Air Search Radar

-SPS-55 Surface Search Radar

-SQS-56 Sonar

-Passive ESM System

COMBINED SENSOR AND WEAPONS DELIVERY

-Two LAMPS Helicopters

The required capability of the above systems elements has been previously established and it is required that their integration into a single combat system shall in no way adversely alter these established capabilities.

5. PF Procurement Phasing

A contract has been awarded to Bath Iron Works Corporation to build the lead ship. Contracts for follow-ship procurements are tentatively to be in two batches of 24 and 25 each over a five-year period. Ship deliveries are to be at the rate of about one per month, with the lead ship being delivered in June 1977 and the last ship of the second block in the 1981-1982 timeframe.

C. PATROL FRIGATE T&E PROGRAM

The T&E phases for the PF are considered to be Developmental Test and Evaluation (DT&E), Operational Test and Evaluation (OT&E) and Production Acceptance Test and Evaluation (PAT&E). OT&E is further broken down into Initial Operational Test and Evaluation (IOT&E) and Follow-on Test and Evaluation (FOT&E).

DT&E is viewed as a class of tests and evaluations for the specific purpose of facilitating the evolution of the ship system and is conducted under the sponsorship of the Developing Agency. For the PF, DT&E is that portion of land-based test site testing concerned with installation and integration of the combat systems in addition to that developmental testing to be conducted in support of the individual equipments. Integration of the combat system is considered to be a "Risk Watch List" item, i.e., failure to achieve satisfactory integration at the test site would adversely affect DSARC III presentation. Integration of the Combat System is to be proved at the test site prior to DSARC III.

IOT&E for the PF consists of two separate areas. First, the individual equipment/systems of the "Risk Watch List" in the DCP are to undergo separate IOT&E's. For instance, the Mk 92 fire control system is scheduled to undergo IOT&E on the USS TALBOT DEG-4 in September of 1974. Second, the integrated systems will undergo IOT&E at the land-based test site. "Risk Watch List" systems which will undergo individual IOT&E are:

-Mk 92 FCS/MK 75 gun mount and 76 mm ammunition

-AN/SPS-49 Radar

-AN/SQS-56 Sonar

-HARPOON Fire Control System

The responsibility for initiating IOT&E for these systems lies with the participating managers (PARM'S) managing the development and procurement of their respective equipment. However, the T&E Manager of the SHAPM's staff will closely monitor the test programs to insure that PF test schedules can be met and that any problems or deficiencies during the IOT&E's are taken into account.

IOT&E of the integrated systems at the Combat System Land-Based Test Site (CSLBTS) is scheduled to begin in January 1975. Naval personnel will be used to evaluate the systems. Accomplishment of adequate IOT&E at the LBTS with satisfactory results is a prerequisite for approval by DSARC of follow-ship procurement. As such, the events and planning leading to IOT&E as well as IOT&E itself will receive the closest attention of the OT&E Organization.

FOT&E will be addressed in detail by an FOT&E Plan which will include the possible requirements and procedures for assigning the lead ship to OPTEVFOR for a complete at-sea operational appraisal prior to the ship's release for Fleet usage. This requirement was embodied in the DSARC I/II decision of 27 September 1972 which stated in part:

The Navy is requested to develop a plan for, and evaluate the impact of assigning the lead PF to OPTEVFOR for a reasonable period to complete an at-sea operational appraisal of the PF as a whole prior to the lead ship's full release for Fleet usage. This plan and evaluation, together with the Navy's recommendations, should be submitted to OSD at the time of preparation of the revision to the DCP for initiation of construction of the first follow ship.

The impact of this assignment will be evaluated and an evaluation report will be prepared by the T&E Planning Group for submission to the CNO. The FOT&E Plan and the evaluation report will be completed prior to the DSARC III milestone.

PAT&E for the PF is functionally separated into three areas. These areas are documentation certification at the LBTS's, acceptance testing and documentation validation on the lead ship, and acceptance testing on the follow ships. Detailed information on the PAT&E is contained in the Ship Test Management Plan of 15 November 1972.

Documentation certification at the LBTS's will consist of actual conduct of test procedures for the installed equipments/systems. Such use will enable test procedures to be corrected if needed and certified prior to use on the lead ship. More will be said about "certification" in a later section of this thesis.

On the lead ship, the certified procedures will be used to conduct the tests leading to validation of the procedures and acceptance of the shipbuilder's efforts. Test procedures for those equipments and systems which were not certified at the LBTS will also be validated on the lead ship. The validated documentation from the lead ship

will then be supplied to follow shipbuilders. Follow-ship testing will use validated test procedures for test conduct leading to Navy acceptance of the shipbuilder effort.

D. PATROL FRIGATE TEST ORGANIZATION

The Patrol Frigate Ship Acquisition Project Manager has established a Total Ship Test Program, and the organization for its accomplishment for the Patrol Frigate. The organization that will be used by the Patrol Frigate to develop test documentation is shown in Figures 1 and 2. The principal members of the organization are identified in this section. Specific responsibilities are elaborated in the next section.

1. Ship Acquisition Project Manager

The Ship Acquisition Project Manager (PMS-399) is responsible to the Commander, Naval Ship Systems Command and the Major Surface Combatant Ship Project Manager (PM-18) for the Patrol Frigate Ship Acquisition.

2. Test and Evaluation Manager

The Test and Evaluation Manager (PMS-399T) is responsible to the SHAPM for the successful conduct of the PF Total Ship Test Program.

3. Total Ship Test Director

The Supervisor of Shipbuilding at Bath, Maine has been designated as the Total Ship Test Director and is responsible for the

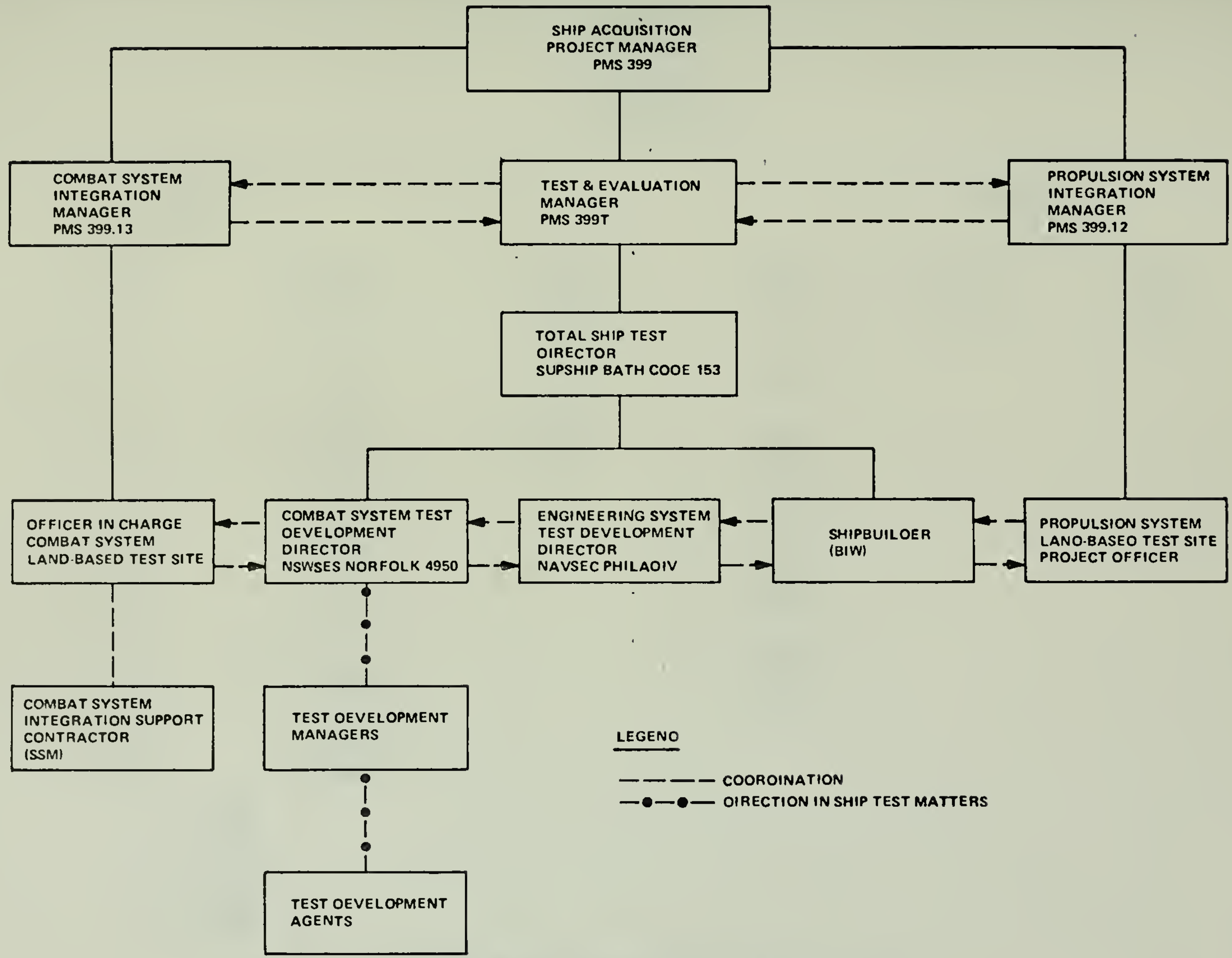


Figure 1. Patrol Frigate Ship Test Organization

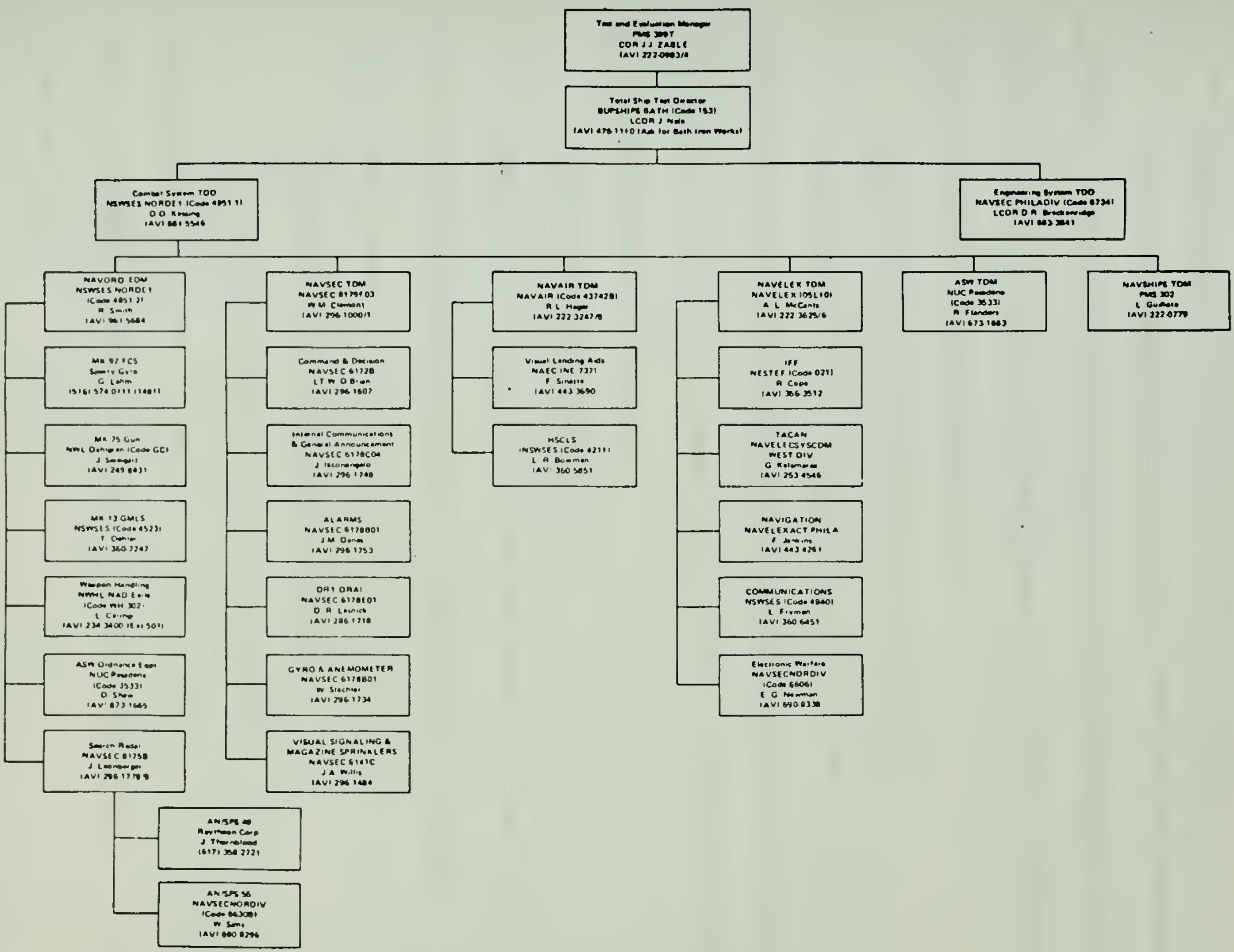


Figure 2. Patrol Frigate Test Development Managers/Agents

development of ship test documentation and its validation on the Lead Ship.

4. Engineering System Test Development Director

The Naval Ship Engineering Center, Philadelphia Division has been designated as the Engineering System Test Development Director, with the responsibility for the development of the Hull, Machinery and Electrical (H/M/E) test documentation.

5. Combat System Test Development Director

Naval Ships Weapon System Engineering Station, Norfolk Detachment has been designated as the Combat System Test Development Director with overall responsibility for the development of Combat System test documentation.

6. Test Development Managers

The Test Development Managers under direction of the Combat System Test Development Director, provide test documentation for specific subsystems of the Combat System.

7. Combat System Integration Manager

The Combat System Integration Manager, PMS-399.13, is responsible for successful integration of the elements of the PFCS and the provision of system level test documentation for the testing of the lead and follow ships.

8. Officer-In-Charge Combat System Land-Based Test Site

The Officer-In-Charge of the Combat System Land Based Test Site coordinates activities at the Combat System Land Based

Test Site with specific responsibilities as described in the next section.

9. Lead Shipbuilder

Bath Iron Works (BIW) has been selected as the Lead Shipbuilder. In that capacity the preparation of various items of test documentation and ship test performance are within their responsibility.

10. Combat System Integration Support Contractor

The Naval Ship System Command has entered into a contract with Sperry Systems Management, Sperry Rand Corporation, as the Combat System Integration Support Contractor to assist the Combat System Integration Manager (CSIM) in the providing of system level test documentation.

E. PATROL FRIGATE TEST ORGANIZATION

1. Introduction

The PF SHAPM has established a Total Ship Test Program for the Patrol Frigate in accordance with existing regulations and which appears in the Patrol Frigate Ship Test Management Plan. This program is to provide for comprehensive tests which will determine the status of equipment readiness during construction and the life-cycle of the ship. The organization that will be used by the PF to develop test documentation is identified in the previous section. Detailed responsibilities of the actors involved in T&E of the PF as presently viewed follows.

2. Ship Acquisition Project Manager

The SHAPM provides guidance as necessary to the T&E Manager in the areas of planning, budgeting, developing, and appraising ship test documentation. The SHAPM is responsible for the PF Ship Acquisition Program and will provide guidance as necessary to the T&E Manager for the implementation of the Total Ship Test Program (TSTP).

3. Test and Evaluation Manager

The Test and Evaluation Manager (PMS-399T) is responsible for the successful conduct of the Patrol Frigate TSTP with specific responsibilities for:

- Successful conduct of the T&E Program
- Generation of the test sections of the Follow Ship Specifications
- Test of the Lead and Follow Ships
- Development and maintenance of the Test and Evaluation Master Plan and Ship Test Management Plan
- Analysis and feedback of the results of testing into ship design
- Development and maintenance of documentation for the testing of Lead and Follow Ships
- Compliance with T&E policy established by the Major Surface Combatant Ship Project Manager (PM-18) and the Commander, Naval Ship Systems Command.

4. Total Ship Test Director (TSTD)

The Total Ship Test Director is responsible to the SHAPM through the T&E Manager for coordinating the development ship test documentation and its validation on the Lead Ship.

The TSTD has specific responsibilities to:

- Manage the development of an Integrated Test Package to ensure that the Follow Shipbuilders comply with the Shipbuilding and Performance Specifications.
- Manage the development of a test package for the life-cycle testing of the PF.
- Prepare and forward Quarterly Progress Reports and Exception Reports.
- Supervise the conduct of testing of the Lead Ship during construction at Bath Iron Works.
- Validate Test Procedures during the testing of the Lead Ship.
- Direct the review and revision of the test sections of the Lead Shipbuilding Specifications and the Test Documentation Booklet for use in the Follow Ship Request for Proposal.
- Direct the activities of the Combat System and Engineering System Test Development Directors in accomplishing the above tasks.
- Submit schedule and budget data to the PF T&E Manager.
- Maintain a configuration control program to ensure availability of correct test procedures for Lead and Follow Ship testing.

5. <u>Engineering System Test Development Director (ESTDD)</u>

The ESTDD has specific responsibilities to:

- Accomplish tasks assigned by the TSTD for development of the Test Index and Test Outlines for Contractor Furnished Equipment for the Lead and Follow Ship Test Programs.
- Provide technical assistance for liaison and monitoring during Engineering System test documentation validation on the Lead Ship.
- Many other duties relating to H/M/E tests beyond the scope of this thesis.

6. <u>Combat System Test Development Director (CSTDD)</u>

The CSTDD has specific responsibilities to:

- Accomplish tasks assigned by the TSTD for development of Combat System test documentation for the Lead and Follow Ship Test Programs.
- Provide for on-site liaison and monitoring during Combat System test documentation validation on the Lead Ship.
- Review the Integrated Test Package and recommend which Combat System Test Procedures are suitable for conversion into Maintenance Requirement Cards for inclusion in the Planned Maintenance Subsystem.
- Provide for on-site witness of the conduct of tests at the CSLBTS and certifying the correctness of Test Procedures.

- As directed by the TSTD, participation in the review, and recommend revision, of the test sections of the Lead Shipbuilding Specifications and the Test Documentation Booklet applicable to the Combat System for use in the Follow Ship Request for Proposal.
- Monitor development of Combat Systems Test Procedures and outlines.
- Review all Combat System test documentation to ensure its technical accuracy and adequacy to support the ship test process.
- Prepare schedule and budget recommendations for the Lead Ship Test Program.

7. <u>Test Development Managers (TDMs)</u>

The TDMs are responsible for organizing, planning, managing, and controlling the development of specific subsystem test documentation for the Combat System. The TDMs are responsible for:

- Managing the development of all equipment and subsystem test procedures for equipment under their cognizance.
- Reviewing Test Procedures for technical accuracy and content.
- Managing the development of special and at-sea trial Test Procedures for external communications, ASW systems, LAMPS, and Harpoon Weapon System, where applicable.

- Ensuring the generation, review, and modification of the Test Index, Test Outlines, and Test Sequence Networks for equipment under their cognizance.
- When directed by the CSTDD, acting as certifying agents at the CSLBTS and validating agents on the Lead Ship for the certification and validation of test documentation for equipments under their cognizance.
- Providing solutions to test problems encountered during the conduct of testing at the CSLBTS and onboard the Lead Ship. The Officer-In-Charge (OIC) CSLBTS and the TSTD have been given authority by the SHAPM to make interim changes to Test Procedures during testing at the CSLBTS and onboard the Lead Ship respectively.

8. <u>Combat System Integration Manager (CSIM)</u>

The CSIM's principal function is to insure the successful integration of the PF Combat System. His primary responsibilities in support of the Ship Test Program, are as follows:

- Provision of special and at-sea trial Test Procedures for certification at the CSLBTS and for eventual Lead and Follow Ship testing as applicable.
- Revision of CSLBTS Test Procedures for Lead Ship applicability and generation of additional Test Procedures for Lead Ship as required.

-Development of Test Procedures for Combat System components installed in Follow Ships and not in the Lead Ship.

9. Lead Shipbuilder

The Lead Shipbuilder is responsible for the following Ship Test actions in accordance with his Contract:

-Review the Test Documentation Booklet and prepare revisions to equipment, subsystem, system and special test outlines as necessary to ensure accuracy and adequacy of Ship Test Program.

-Develop Test Procedures for Contractor Furnished Standardized equipments.

-Develop Test Memoranda for CFE.

-Conduct Combat System equipment, subsystem, system and special test procedures onboard the Lead Ship. Deficiencies shall be brought to the attention of the SUPSHIP, Bath.

10. Officer-In-Charge Combat System Land-Based Test Site (OIC CSLBTS)

The OIC CSLBTS is responsible to the SHAPM, through the Technical Director, for the overall management and operation of the Navy assets at the CSLBTS. In support of the Ship Test Program, he has the responsibility to:

-Demonstrate, where feasible, Combat System test procedures at the CSLBTS for certification prior to use on the Lead and Follow ships.

-Schedule tests and demonstrations.

-Supervise the evaluation of proposed changes to Combat System Test Procedures at the LBTS.

11. Combat System Integration Support Contractor

Test responsibilities of Sperry Systems Management as the Combat System Integration Support Contractor includes:

-Develop unique subsystem, system and special Test Procedures for the Combat System, initially for use at the LBTS and eventually for use during the Ship Test Program.

-Provide maintenance assistance and engineering support during certification of equipment, subsystem, system and special Combat System Ship Test Procedures at the LBTS.

-Evaluate proposed changes to Combat System Test Procedures at the LBTS and forward results with recommendations to the TSTD via the CSTDD.

-Provide the TSTD technical support if required during the conduct of Test Procedures on the Combat System for both the Lead Ship and Follow Ships.

Highlights of the present Navy contract with Sperry Systems Management will be provided in a subsequent chapter of this thesis.

F. CONCLUSIONS

Requirements set forth in DODD 5000.1 and current Navy Department Directives provide the required Patrol Frigate test and evaluation

guidance with which to establish a ship/system T&E approach which demonstrates, at various decision points, sufficient confidence for follow-ship commitments. The PMS 399 organization for T&E has the capability of providing for successful acquisition of 50 mission-capable Patrol Frigates with performance-validated ship's crews, ship's hardware and software.

Effective implementation of the PF T&E program concept requires centralized authority and responsibility in one agency acting for and under the direction of the SHAPM. This has been provided by a Test and Evaluation Manager. One caveat however, is in order and is in reference to behavioral considerations of participative management as employed by the PF T&E organization. The SHAPM's T&E organization is predominately a military/civil service organization and its managers have had a lifetime in military and government affairs. In such organizations it is often a rule not to bring up problems that do not already have apparent solutions. The essence of participative management in the PF T&E program is openness and freedom of exchange of both problems and problem solutions. Centralized top management seeks this, but it does not come naturally and requires perceptive treatment by all who are involved.

Another area in which the PF program is vulnerable stems from the ever increasing number of Congressional, DOD and Navy-mandated programs. Previous chapters have dealt with T&E aspects. Similar

forces are at work in other areas such as integrated logistic support, value engineering, surplus labor area selection, small business withholds and shipbuilding. Across the board PMS 399 is particularly vulnerable to those programs which are aimed at increasing centralization of weapon system procurement. While PMS 399 will support these programs, they have a significant impact on planning because they are often of great scope, unfunded, absorb scarce and crucial resources, and decrease the SHAPM's planning self-determination.

VI. THE PATROL FRIGATE COMBAT SYSTEM LAND-BASED TEST SITE

A. GENERAL

Land-based integration of the Patrol Frigate combat system is a keystone of the PF T&E program. Prior to the production decision (DSARC III), presently scheduled for March of 1975, the Land-Based Test Site will be used to prove installation procedures to the maximum extent practicable and to prove the mechanical and electrical compatibility of the major equipments of the combat system. Additionally the Combat System Preliminary System Operational Program will be demonstrated at the CSLBTS. The Final Operational Program will be debugged at the LBTS, after DSARC III, and will be demonstrated onboard the lead ship after delivery.

Proofing of computer programs will be emphasized as a major factor in achieving full utilization of the integrated combat system. Engineering and functional analysis at the LBTS will lead to early solution of integration problems that may be exposed.

An attempt will be made to address critical test and evaluation questions and issues identified in the DCP such as:

-Are the individual combat subsystems which are to be incorporated in the ship technically acceptable and operationally suitable and effective?

-Is the integration of the various combat systems through their respective interfaces adequate, in terms of data transfer characteristics such as handling capacity, rate and quality, to meet operational requirements?

-Do those operational characteristics of the integrated combat system which can be estimated based on initial operational test and evaluation, including reliability and maintainability test and evaluation, show a reasonable probability that the ship class, when afloat, will be able to satisfactorily accomplish the mission for which it was designed?

The use of a land-based test site as an aid in ship procurement is not a new concept. As early as 1958 an ashore navigation center was constructed by Sperry Systems Management Division in support of the SSBN 598 class of submarine construction. Test sites employing specific equipments are presently available at additional locations such as Mare Island. However, the PFCSLBTS is the first site constructed which is dedicated to a single class of ship.

Recent experience with the DLGN-36 class procurement has reinforced the need for a dedicated test site. A review group under the banner of the CNM recently (14 March 1974) completed an audit of the problems found in the DLGN-36 combat system. Throughout the report it is repeatedly pointed out that the lack of a LBTS seriously hampered and delayed successful combat system integration.

For the DLGN-36 procurement and others (DD-963, DE-1052 etc.), land-based testing was conducted on a fragmented subsystem basis. Some subsystems were partially tested at Mare Island for instance, and others at Dam Neck. In neither case was there a "full up" capability for testing the complete combat system. The first time the major subsystems were all brought together at one place was aboard ship. Since there was no land-based test site, the full up system problems were not encountered until the advanced stages of shipboard testing. Such is not the case for the PF procurement program.

B. PATROL FRIGATE LAND-BASED TEST SITE PHYSICAL PLANT

The LBTS is located at MacArthur Airport, Islip, New York. Its primary initial function is to serve as a facility for the integration of the combat system equipment and for training a U. S. Navy crew to demonstrate the system prior to the PF production decision. It is anticipated that, following the production decision, the LBTS will be used for crew training, shipyard personnel training, computer program verification, change verification, test program checkout, etc. The LBTS will also be used for design and test of system modifications.

The building which houses the LBTS contains the physical mock-up (PMU) compartments for the PFCS, the test facility for the Mk 92 FCS, and facilities for support of these activities. In addition, the LBTS contains the offices and classrooms required to support this plan.

Appendix B depicts the location of the test site in relation to MacArthur Field, a layout of the test site, a plan view of the CIC and sonar control room, the CIC, IFF and sonar equipment room, the Mk-92 equipment room, the STIR (Separate track and illuminate radar) equipment room, the operations center (OCC), the program checkout area (PCA), and the Mk-92 test site. Radar antennas are physically located on the northern side of the test center in the approximate configuration that they will appear onboard ship with the exception of height which is limited by FAA regulations.

The physical mock-up compartments will contain actual operating equipment as well as simulators and mock-ups, and will represent the precise configuration of the ships compartments. The CIC physical mock-up contains functional communications circuits to enable the simulation of tactical operations. The LBTS also employs functional SPS-49, SPS-55 and Mk 92 Mod 2 CAS (combined antenna system) and STIR radars. It is thus capable of detecting and tracking actual aircraft. No capability exists, however, for actual subsurface targets and only a limited capability exists for surface targets. Ships motion, as well as air, surface, and subsurface targets can be simulated by an OCC Console and inserted into the command and control element of the combat system. Based on these simulated data inputs, the combat system will develop CIC console scope presentations and data readouts depicting test or tactical operation scenarios. Operator actions will

result in selection and ordering of simulated weapons. During the performance of the exercises, CIC operator actions and displayed console data can be monitored, recorded, and evaluated through use of closed circuit TV, PPI displays, data readouts, and recording equipment on the OCC console.

The PMU is realistic to the point of being deceptive, and only the lack of ships motion and the smell of salt air detract from almost complete authenticity.

C. USES ENVISIONED FOR THE CSLBTS

1. DSARC III Demonstration

As previously stated, the primary short-range use of the LBTS is to prepare a presentation for the production decision at DSARC III. In fact, there are those close to the PF project who believe that the production decision hinges almost completely on how well the CSLBTS reacts to the scenarios during the presentation. In preparation for this demonstration, a Navy crew is presently undergoing training under Sperry guidance to gain the knowledge and skills necessary to demonstrate satisfactory operation of the PFCS during the IOT&E demonstration. A limited number of COMOPTEVFOR personnel will also attend this training.

2. Training

This training includes the following:

- The characteristics of the PFCS and the LBTS, to include system capabilities and limitations, mission, combat system elements, subsystem elements and manning.
- Combat system functional data flow, including the signal characteristics and time relationships.
- The IOT&E tests to be performed on the PFCS including threats, test method and test procedures.
- The theory needed to support and understand the performance of operational procedures, for detection, identification, evaluation, weapon assignment and weapon control under various threat conditions.
- The theory needed to perform operational trouble analysis and fault isolation to the subsystem/equipment level by employment of system operational tests and programmed operational functional appraisals and by logical analysis using maintenance documentation.
- Documentation and procedures to support system level organizational maintenance.
- Ability to perform normal and casualty operations on an assigned station with an acceptable probability of successful target engagement, for each of the following scenarios:

--Power up, Condition 3.

--Work station checkout, Conditions 3 and 1.

--Single aircraft attack, Conditions 3 and 1.

--Single surface/near surface attack, Conditions 3 and 1.

--Single subsurface attack, Conditions 3 and 1.

--Multiple threat, Conditions 3 and 1.

--Casualty mode, Conditions 3 and 1.

-Ability to perform trouble analysis and fault isolation of PFCS faults to the equipment level, using diagnostic computer software and maintenance manuals.

-Ability to perform system level organizational maintenance.

-Ability to perform the IOT&E, with acceptable accuracy and within specified time limits, using specified methods and procedures.

The objectives of the lead shipbuilder course is to familiarize shipbuilder personnel with the PFCS and to provide them with the unique skills and knowledge required to install, integrate, and check out the combat system on the Patrol Frigate. The follow shipbuilder course will be the same as the lead shipbuilder course except for modifications to accomplish curriculum improvement, as necessary to reflect shipboard configurations, or as required by the follow shipbuilders.

As a training vehicle, the LBTS is limited by the following considerations:

-Until U. S. Navy certification 15 December 1974, priority of use of facilities and equipment is assigned to engineering development, system integration, and testing.

- After 15 December 1974 and until IOT&E is completed, priority of use will be assigned by the U. S. Navy OIC of the LBTS.
- The LBTS equipment complement does not include all shipboard CIC equipment. Simulation is provided in lieu of major system inputs such as sonar, ECM, ships motion, and weapons dynamics. Mock-ups are provided for major equipment found in the shipboard configuration but not essential to combat system IOT&E.
- Unscheduled (corrective) maintenance will be performed by Sperry engineering and contractor technical support rather than U. S. Navy personnel.
- Deliberately faulted modules will not be available or authorized for use in the system prior to or during the IOT&E.

3. General areas

The specifics of the majority of the tests to be conducted at the LBTS are classified. However, the LBTS will be used as a test bed to address the following type of questions:

- Can the PF develop attack data on submarines by the use of active sonar while maintaining speeds up to X knots?
- Can the PF decoy passive acoustic homing torpedoes?
- Is the PF capable of employing ASW weapons to the effective range of installed subsurface sensors?

- Is the PF capable of controlling HS/VS/VP aircraft?
- Is the PF capable of detecting airborne threats by use of radar?
- Can the PF detect and evaluate electromagnetic radiation?
- Is the PF capable of tracking and engaging fighter-bomber type aircraft?
- Can the PF track and engage air, surface or sub-surface launched anti-shipping missiles?
- Is the PF capable of engaging surface targets to over-the-horizon ranges?
- Is the crew capable of performing all combat systems operations?
- Is the crew capable of performing all combat system maintenance tasks?

4. Documentation

One of the most difficult and expensive areas to manage in the procurement of a new combat system is documentation, especially at the system level. The PFCSLBTS will aid documentation as follows:

- Generation of publications engineering data and text.
- Verification of system documentation for builder and fleet use
- System Documentation
    - -Technical manuals (system and equipment)

--Standard operating procedures

--SMP's (System maintenance procedures)

--PMS (Planned maintenance system)

--System computer program and documentation

--System and equipment diagnostic computer programs

-Data flow and one-function diagrams.

5. Logistic support

Logistic support for equipments in combat systems are often based on engineering data and test bench operation by equipment manufacturers. For the PF there is a Failure Data Collection, Analysis, and Corrective Action Plan which is designed for the unique requirements of the Land Based Test Site while permitting the acceptance of data from vendor facilities, shipbuilders, government sources and eventual fleet operations. This plan incorporates failure data collection, failure analysis, corrective action, and failure reporting. Thus it may be viewed as a dual-loop system whereby better logistic support requirements may be determined initially based on LBTS data and in the long run on a system whereby continuing assessment of support requirements based on fleet data may be made.

6. Long term uses

Sperry's experience with the SSBN 598 class ashore-navigation center seems to indicate that in the short run the configuration of a given LBTS closely duplicates the class of ship for which it was built.

As time goes on and other classes of ships come into being, there is a tendency to modify existing LBTS to accommodate ashore testing of new systems. In this regard, the LBTS is a vehicle to groom tactical equipment, and verify installation test procedures and system computer programs. It supports system improvement studies, development of new system concepts, and analysis of advanced system computer program concepts. In development areas, the LBTS may be used to test and evaluate new operational techniques, system-equipment changes, define change requirements, evaluate proposed changes, and to verify shipalt/ordalt change documentation and accuracy.

7. Land-based Test Site Users

While the total spectrum of users of the PFCSLBTS can only be determined after the fact, it is envisioned that many types of activities will use the LBTS to advantage. Users envisioned at the present time include procurement decision makers, system designers, system analysts, system programmers, equipment contractors and subcontractors, publication agencies, integrated logistic support personnel, fleet personnel, field engineers, and shipbuilders. In addition, reliability managers, those involved in quality assurance, and politicians are sure to make use of the facilities available at the LBTS.

D. GOALS OF THE PATROL FRIGATE LAND-BASED TEST SITE

The initial goal of the PFCSLBTS is to adequately demonstrate the viability of the proposed combat system to the DSARC at the production

decision and thus support fleet requirements in the 1980's and 90's. The other side of this goal, so to speak, has a negative connotation. To wit, if the system is not viable, it will not be procured. Within the initial goal, there are many subgoals present. These subgoals include saving money and time, and to ensure design soundness, requirements, and equipment system compatibility. Additional goals include the verification of publications such as system operating and maintenance procedures, and system computer programs. Finally, it is a goal of the LBTS to provide the means to evaluate equipment performance and to solve system technical problems before they develop in the fleet and when they do, to provide a system to investigate and resolve them quickly.

E. THE LAND-BASED TEST SITE CONTRACT

Sperry Systems Management, an operating unit of Sperry Division, Sperry Rand Corporation, presently holds a $12 million dollar contract with Naval Ship Systems Command (NAVSHIPS) covering their effort in support of the PFCSLBTS. Some highlights of that contract (#N0024-73-C-1089) follow.

1. Test and Evaluation

Sperry Management Division is required to design, erect, and operate the land-based test site. The LBTS is to be used as a facility for integration and validation of the PF combat system prior to the

PF production decision. The Mk 92 MOD 2 fire control system being produced by the contractor under separate contract is the principal element of the combat system. The CSLBTS will be used for acceptance evaluation of the Mk 92 FCS and its subsequent integration with the GFE elements, simulators, switchboards and ancillary equipments of the PFCS for test validation and certification of the PFCS.

2. Construction of the LBTS

The LBTS is to include training facilities and the contractor shall define and provide system simulators and programs required, prepare equipment program specification, statements of work and all other contractual documents necessary for procurement of the LBTS construction. The contractor will check out simulation equipment and programming to ensure adequate performance to tactical equipment's specifications.

3. Support activities

Under direction of the Navy OIC of the LBTS, the contractor is to provide a technical director to operate and maintain the LBTS and PCA, as a development demonstration proofing site for the PFCS. The contractor shall provide all facilities required by the OIC for the LBTS to include provision for and maintenance of the office space required by the OIC, provision for reproduction services, provision for clerical and custodial services, provision and maintenance of appropriate security services and precautions.

4. Repair parts

The contractor will be provided spare and repair parts as determined by the government for government furnished equipment.

5. PFCS Integration and Test

The contractor shall integrate the Mk 92 MOD 2 FCS produced by the contractor under separate contract with government furnished computers, display, console sensor and other elements of the combat system at the LBTS. The contractor is required to verify the integration of the combat system at the LBTS in accordance with a test plan to be provided by the contractor and approved by the Navy. The test plan shall be developed from an integrated test outline furnished by the Navy and shall be directed toward the verifying of combat system performance including the PFCS performance specification provided by the Navy. The contractor shall provide all test maintenance, computer support personnel, and such simulation programs as are required for the performance of this task. The contractor shall also collect, compile and analyze all data and prepare reports as required. The contractor shall develop appropriate test plans for performance of the IOT&E demonstration and submit the test plans for SHAPM approval.

6. LBTS Operation and Demonstration Support

The contractor shall support Navy personnel as required in performing the IOT&E demonstration at the LBTS. The contractor shall support other demonstrations and evaluations conducted at the LBTS under direction of the OIC. The contractor shall staff and

operate the LBTS facility under supervision of the OIC after completion of the initial PFCS integration, testing, certification and IOT&E demonstration as a test development and training center. The facility will be utilized to support the PFCS in all areas requiring the use of an operational test bed. Area use anticipated for the LBTS includes:

- Documentation development and verification
- Combat system crew training for follow ships
- Special demonstrations
- Investigation of combat system changes
- Prove out of ordalts and shipalts
- Fleet combat system problem investigation
- Integration of growth items
- Shipyard support.

7. Test Procedures

Utilizing the integrated test outline and the combat system performance specification prepared by the Navy and furnished to the contractor, the contractor shall prepare and maintain a current test and evaluation plan, and a set of test procedures for use in the operation, test, evaluation and demonstration of the PFCS at the LBTS and eventual use on the lead ship. The test plan and procedures shall cover the following:

- Incoming inspection of GFE
- Unit test of GFE

- Subsystem testing of GFE
- Integration of the Mk 92 MOD 2 FCS produced by the contractor under another contract with material furnished under this contract and the GFE in the LBTS.
- Combat system test demonstration at the LBTS.

8. SHAPM Support

The contractor is required to support the SHAPM in the development, test and evaluation of the PFCS by maintaining control of the configuration of the PFCS at the LBTS until satisfactory completion of the IOT&E demonstration. The contractor is required to furnish technical support to the lead ship builder in the design of the PFCS compartments. He is required to assist the SHAPM in the resolution of problems directly associated with the PFCS, specifically in the area of integration analysis, documentation, ship test planning and development, combat system reliability and maintainability and availability analysis and evaluation.

The contract as outlined above expires in March of 1975 after the scheduled DSARC III presentation. It is conjectured that the contract will be extended on at least a yearly basis in support areas.

VII. SOME PFCSLBTS CONCEPTS AMPLIFIED

A. GENERAL

Contracts, test plans, operating procedures and Congressional testimony in general address the theoretical side of procurement; what is planned or ought to be rather than what is. Since the Patrol Frigate LBTS can be viewed as a prototype of land-based test sites for future ship procurements, it is of interest to get behind the scenes to the grass roots level of test site concepts. Information presented in the following section is an attempt to document the beliefs, gut feelings and thoughts of a myriad of individuals and commands contacted and/or visited during research for this thesis. The author and the author alone is responsible for the inferences contained herein.

B. A COLLAGE OF QUESTIONS INCLUDING A FEW ANSWERS

1. What working relationships have evolved between the LBTS OIC and SHAPM (PMS-399), Sperry NAVPRO etc. in the three month period the LBTS has been manned with Navy personnel?

The OIC's marching orders at this early point in the LBTS life are essentially to get the job done. Since the concept of what the job is is evolving in parallel to the LBTS, tasks have not been formalized to any great extent, nor should they be. At the present time the OIC has broad duties and freedom in his actions. He has submitted a

one-page recommendation as to what his duties should entail, and PMS-399 is in the process of integrating this input into a more formal job description.

At the present time the OIC reports to NAVSHIPS as an OIC, and to PMS 399 as PMS 399.16, OIC of the PFCSLBTS. The NAVSHIP reporting chain enables the OIC to receive support such as being on the SNDL (Standard Navy Distribution List), have his own UIC (User Identification Code), and enables him to receive outside assistance that could be cumbersome to receive via the SHAPM chain. The day-to-day chain of command is through PMS-399 and it is through this chain that fitness reports will be generated.

The OIC is administratively supported by the NAVPRO office at Sperry Great Neck, some 50 odd miles from the LBTS. This support presently takes the form of Naval communication support, NAVPRO PF/MK 92-2 contract inputs, and various other administrative support items. The NAVPRO is administering the Mk 92-2 contract with Sperry, but the PFCSLBTS contract is being administered by contracting personnel on the SHAPM's staff and by NAVSHIPS 025.

The OIC's relationships with outside activities such as NAVSEC, OPTEVFOR etc., generally falls in the area of assisting Sperry Management Division in the prosecution of their contract. Informally, the OIC assists whomever he can. For instance, assistance is being provided to NAVORD personnel in tracking NAVORD's portion of the Mk 92 procurement contract.

The OIC is on a razor's edge between those who recognize a need in the fleet for a ship weapons system such as the PF and those who are test oriented, and at the extreme test for testing's sake. The former group are equipment/production oriented and include both producers of combat system equipment such as Sperry and operational personnel who perceive that the system, albeit with short falls, is better than what is presently in the fleet. The latter group, the "testers", many times have to devote much time supporting the rationale of T&E reports before GAO, Congress, and the Office of the Secretary of Defense to prevent misinterpretation. The reporting of T&E results culminates the T&E cycle and forms the basis for various decisions concerning the future status of the weapon system. For example, IOT&E reports are used by Congress as set forth in PL 92-156, and by the DSARC as an input for the major production decision. They are also used by COMOPTEVFOR to support the suitability of a proposed system to meet fleet needs and operability requirements.

In view of the importance of T&E, different agencies have different emphases in the conduct of the T&E. A grouping of the thrust of T&E needs could be the cost-effectiveness group versus operators and producers. Within the operator/equipment side, the LBTS OIC as stated in Chapter V has authority to make changes. Once the test group presents the OIC with a test plan for IOT&E and DSARC III demonstration, the OIC becomes an instrument of the test group and his ability to alter plans is severely limited.

2. What authority does the OIC have within the boundaries of the contract? What is his relationship to testing and test and evaluation activities?

Authority to make changes in contractual obligations is severely limited, as it should be, in that the OIC does not have the resources to carry out complex changes. The OIC can make changes that involve no change in the scope of the contract and upon which Navy direction is required. PMS-399 maintains centralized authority to make contract changes.

Since the effort required to derive proper tests and test procedures was underway long before the OIC reported to the LBTS in January 1974, the OIC had no input into test development. He has however, become deeply involved in the evaluation of the CSOT (Combat System Operability Test), which will be conducted by Navy personnel both at the LBTS and throughout the life cycle of projected ships.

The OIC views testing at the LBTS as a three-phase effort as follows:

-Tests leading up to Navy acceptance/certification of the LBTS in December 1974. Sperry is conducting these tests based on outlines supplied by the Navy. The purpose of these tests is to demonstrate a total integrated combat system to the Navy as witnessed by the OIC.

-IOT&E tests. The purpose of these tests is a demonstration by the Navy to DOD and DSARC III of the operational characteristics of the combat system. The tests will include scenarios, simulated aircraft, and actual aircraft engagement. The OIC and Navy personnel will conduct these tests. The tests will be developed by PMS-399, APL (Applied Physics Laboratory), OPTEVFOR, and other agencies.

-Prove out and conduct lead ship tests. These tests, from the Total Ship Test Program (TSTP), will be conducted to verify that the lead ship can indeed be checked out and delivered in an up condition. These tests will be conducted by the OIC and Navy personnel.

At various stages in the test phasing outlined above, different agencies will be involved in the actual data collection, data reduction, and analysis. These responsibilities are presently being considered.

3. What formal and informal relationship exists between the OIC of the LBTS and other NAVPRO personnel?

There is no formal relationship such as one would find on an organizational chart. The OIC is working with the NAVPRO toward acceptance of the PFCS by the U. S. Government. There is presently under preparation an agreement between NAVSHIPS and the Sperry NAVPRO whereby the NAVPRO would be tasked to assist the OIC in all technical matters relating to the LBTS.

4. What is the status of follow-on contracts with Sperry Management for such things as life cycle support of the program?

Review of the present contract and the substance of future contracts will come under scrutiny in the fall of 1974. Unlike most contracts, it is envisioned that the contract for life cycle support of the program will be a multiple year contract.

The LBTS is viewed as a ship permanently home ported in Sperry's building at MacArthur which the Navy runs. Sperry and other industrial support is viewed much like what afloat units receive from tenders and ship yards.

5. How will personnel be cycled through the LBTS for training?

A solid long range plan has not been developed at this point in time. Up through IOT&E, there will be a crew of about 22 men including three officers and one Wave resident at the LBTS. These people will constitute the Navy crew for the DSARC III demonstration, and then will eventually be assigned to the lead and follow ships. In parallel, additional people will cycle through the LBTS for training.

About six to twelve sailors will be permanent residents of the LBTS under one officer in the grade of LCDR/CDR. They will operate and maintain the site and cycle through changes etc. as required.

It is planned to instruct civilian workers from the three builders who win the PF procurement contract in all aspects of the installation and tests required by the PFCS. These individuals in turn will supervise installation and test of the PFCS at their respective

building sites and instruct Navy precommissioning crews. These crews in turn will form the nucleus of the crew that takes the ship through trials and eventually to the fleet.

6. What impact would stretching out of the production decision at DSARC III have on operation of the LBTS?

The LBTS was primarily built as a vehicle to demonstrate the PFCS at DSARC III, and in the long term, to support the life cycle of the ship. In this regard, at least in the short run, activity at the LBTS is directed toward the DSARC III presentation. These activities of themselves should be the cause for any delay of the production decision at DSARC III, rather than DSARC III causing the stretching out. Other than a complete cancellation of the PF program then, the LBTS is here to stay.

7. What is considered to be the "salvage value" of the test site?

Assuming that the program receives a green light at the production decision, a realistic salvage value cannot be assigned to the site at this time. That can only be really determined when the site is closed down.

The major purpose of the LBTS is to determine if it is feasible to do what you want to do. In effect money is being spent now so that fifty times as much isn't required in the future to obtain the same results, whether good or bad. The $12 million or so invested in the LBTS is certainly a small cost in comparison with a projected cost of over $3 billion for the fifty ship buy.

8. How closely does the LBTS duplicate both human and machine operations of the combat system aboard ship?

It is the intent to duplicate as closely as possible shipboard conditions. Equipment limitations and the use of simulation was addressed in Chapter 5. From the human aspect, the LBTS is almost identical to a shipboard installation down to fire extinguishers on the bulkheads and Playmates posted in switchboard doors.

Environmental factors preclude bringing jet aircraft against the site at high speeds and low altitudes, and simulators will have to be relied upon heavily for such tests. However, real life tends to be not as confusing, mixed up, nor saturated as the situations presented via simulations. In simulations, the kitchen sink can be thrown in but realistically, there are only so many aircraft that can come at you, and they are as confused as you are as to what the situation is.

9. What will be the training status of the crew used for the DSARC III demonstration?

For the PFCS, this question lends itself naturally to another one. How can a combat system be tested under ideal conditions when the training period leading up to the test period is minimal? Are you testing the combat system or are you testing the training of the demonstration crew?

At the LBTS, the Navy crew will have approximately one month "hands on" training prior to the start of IOT&E. In this short time frame, they will be required to reach a level of competency often not

reached by fleet units during a six month buildup and several weeks of refresher training.

Additionally, there exists an educational/technical gap between Navy and contractor T&E personnel. The contractor is represented by well-paid, highly experienced, and technically competent engineers and technical support personnel, which gives him the edge in structuring the T&E effort to his contractual advantage.

10. How is approval for service use as a result of DSARC III, and the Board of Inspection and Survey (BIS) acceptance for service use from acceptance trials viewed by LBTS personnel?

Sperry and LBTS Navy personnel understand that they are assembling a combat system to accomplish the mission required. Their effort is directed toward making the beast work. The BIS in its acceptance trials tests not only how well the combat system performs its assigned tasks, but brings in points of contention such as whether a certain light should be red or amber, are phone jacks located in accessible places (even though they may have been located in accordance with MILSPECS), and other such considerations.

Admiral Zumwalt, testifying before a hearing on Cost Escalation in Defense Procurement Contracts in 1973, stated that he had command of a destroyer in 1957 which was one of 100 consecutive destroyers found to be unsatisfactory by the BIS. "Yet my ship won the efficiency pennant in every department of the ship and the battle

efficiency pennant and yet if you read the INSURV report, we couldn't go to war."

The best way to handle deficiencies is to make sure they never arise in the first place because of design or fabrication shortfalls. Thus it appears that there should be a closer relationship between BIS personnel charged with acceptance of systems and personnel involved in presenting a system to the DSARC for service approval.

11. How flexible is the site for expansion of PF projects? For alteration to similar ship systems?

The PMU is a physical model of the actual PF shipboard spaces. As such it is a very useful tool to aid in determining the space allocation requirements for growth items. The LBTS itself is space limited to a certain degree within the existing building if it is desired to build PMU's of other classes of ships. However space does exist whereby equipment could be placed on pallets and connected to the PCA to conduct various equipment/computer interface tests. Real estate wise, grounds exist to extend the existing building by a considerable amount.

12. What systems will be taken from the LBTS to Bath for installation aboard the lead ship? Will specific subsystems be tested/integrated at the LBTS prior to being sent to the shipbuilders?

There is a possibility that all the equipment comprising the PMU installation will be sent to Bath for installation aboard the lead

ship. In this manner, shipboard installation and check out would have as its basis a completely checked out combat system. Presently under consideration is what specific subsystems, if any, should be cycled through the LBTS prior to shipboard installation. Even a partial cycling of critical units through the LBTS would improve configuration control, enhance check-out of the equipment, and provide an opportunity for LBTS personnel to bring equipment up to the latest change status and conduct system level tests on the equipment integrated into the system.

Contractors and shipbuilders are instructed to install GFE in ships. Often the equipment to be installed has not been adequately modified to reflect the latest change status, or parts are missing. The LBTS has not escaped this either. For instance, the CWI units for the Mk 92 FCS were received without several cards and/or drawer components. Often such equipment is installed and equipment/sub-system level tests are in progress before it is discovered that a crystal buried in the back of a chassis is missing. Cycling high risk items through the LBTS would help to alleviate this problem.

Another concept that merits consideration encompasses the cycling of equipment through the LBTS where it could be checked out by a verification and test team. This same team could follow the system on board ship where they would be responsible for integration testing. Such an approach would definitely reduce test time and since

the follow ships are scheduled to go down the ways at the rate of one per month, it is feasible from a manning standpoint.

13. How were the following site selection criteria decided?

-Cost effectiveness (stressing maximum utilization of existing assets consistent with the mission of the facility employed)?

Once Sperry received the contract to design, build and operate the PFCSLBTS, the decision as to where the test site should be located was Sperry's. Thus cost effectiveness has to be viewed from Sperry's viewpoint and this information is not available.

-Minimum MILCON requirement.

It is understood that one of the factors leading to the decision to place Sperry under contractual obligation to build the test site with R&D funds was the long lead time required to obtain funding via MILCON channels. MILCON funding requirements were thus minimized (zero), but whether or not a greater amount of R&D funds were required to erect the LBTS is unknown.

-Adequate source of professional talent and skilled labor, good housing, and community services.

Once again such considerations were made by Sperry. It is understood that considerations such as those listed above came to bear in Sperry's decision, but again, this information is not available.

-Availability of fleet computer programming groups.

It does not appear that this was a consideration. UNIVAC is tasked with the development of programs, and Sperry with the running

and check out of these programs. While Navy fleet computer groups are monitoring the progress and will become actively involved in the certification of the PFCS, it does not appear that their availability was a factor in site selection.

-Availability of fleet units in the area.

This was not a consideration as can best be determined.

-Availability of controlled Navy aircraft services with minimum airspace restriction.

Sperry has previously used the area in which the PFCSLBTS is located to conduct tests on the AN/SPG-55B Terrier FCS. Based on this experience it was postulated that adequate aircraft services could be obtained to support PFCS tests. It is obvious that more realistic flight paths could be programmed if the LBTS were remotely located, and this is another tradeoff that was made in site selection.

-Easy accessibility coupled with good security.

Again this was a Sperry decision. Under the terms of their contract Sperry is responsible for providing security at the LBTS. No fault can be found with their system which consists of a badge and sign in/out log. Visitors must be signed in by site personnel and escorted. The site itself is easy to reach and more than adequate parking is provided.

-Near large body of water (for electromagnetic propagation considerations).

There is no problem in this area on Long Island.

-Controlled electromagnetic environment.

Sperry conducted many ECM/ECCM checks on the AN/SPG-55B FCS. While the environment around the LBTS can be controlled only to a limited extent, it must be remembered that the radars associated with fire control systems operate in a frequency range not normally employed by civilian activities. As such then, little interference with FCS ECM/ECCM testing is anticipated.

-Accessibility to collocated NAVSEC engineering groups and SHAPM.

Unless the LBTS was located in Washington, the present location is as good as might be expected. It is located a stone's throw from MacArthur Airport and airline schedules to and from Washington are such that people coming to the LBTS from Washington can arrive in the morning and depart in the afternoon with a minimum of delay.

14. How will the test site be certified? What does certification of the test site mean? Are the simulations being used certified?

The LBTS will be certified by a certification activity designated by PMS-399. At the present time (March 1974) it looks like this activity will be the eastern detachment of the Naval Ships Missile System Engineering Station.

Certification, as defined within PF Programs, is the process of conducting a test procedure at the PFCSLBTS (or other facility) in order to ensure that it is correct, accurate and complete with respect

to the equipment being tested. A test procedure will be certified as being correct on satisfactory completion of certification. Certification of the PFCSLBTS in essence means that the site has been tested as a combat system and the results of these tests show that the site does indeed operate as the combat system designed.

Simulations being used at the LBTS at the present time do not have a certification in the sense of acceptance via testing in accordance with an approved test plan. Sperry is developing a plan to demonstrate that in fact the simulations represent actual equipment. In the sense that individual simulations support the overall conduction of certification tests, the simulators will be certified at the time the PFCSLBTS is certified.

15. What factors will be introduced during testing to simulate power fluctuations, power failures, heat and cold, air conditioning failures, chill water that isn't chilled, etc.?

None. Environmental testing to required specifications is to have been completed during equipment manufacture and test. Deliberate failures are not planned to be introduced during the course of testing at the LBTS. The site is powered from the Long Island Power Company, and this power is thought to be less regulated and more apt to drop than shipboard power. There will probably be a sizeable number of other type failures encountered in the normal course of events.

In summary, this section attempts to pose some pointed questions concerning the PFCSLBTS, and to provide some answers. Life being what it is, there always appears to be more questions than answers. Much was left unquestioned and unanswered such as: "What is the value and what has been said and done about the necessity of developing and retaining, permanently, within the Navy, the expertise required to integrate a combat system?"; "How will the LBTS be integrated with BIS and OPTEVFOR for lead and follow ship testing?" and "What are the real cost/effectiveness considerations for the LBTS?"

VIII. CONCLUSION AND AREAS FOR FURTHER CONSIDERATION

A. GENERAL

This thesis should be considered neither a compendium of combat system test and evaluation nor a handbook of solutions based on the approach of the Patrol Frigate program via a land-based test site. It does trace emerging doctrines encompassing ship acquisition T&E and investigates the PFLBTS as an innovative approach to a practical solution. The complexities of modern shipboard combat systems have been discussed as has efforts to formalize the test and evaluation requirements for these systems. To date however, the strides that have been made in T&E are due largely to the confiction of the managers involved. The use of land-based sites in T&E investigated in this thesis has been developed from an empirical rather than a theoretical analysis. Successful implementation of T&E policy must be based primarily on past experience, and personnel involved with ship T&E policy should have some background in ship acquisition programs both from a theoretical and a "hands on" base. This will allow thorough attention to proposals for future improvements that will continually be present in this emergent field.

B. SIMULATION AT THE PFLBTS

In recognition of the cost to procure, install, operate, and maintain a total ship combat system, including all its sensor and weapons

subsystems, the PFLBTS relies on simulation for interface testing of certain hardware and software items. This imposes limitations on the facility; these limitations appear acceptable in that the PFLBTS has consistently retained the option, within funding constraints, for installation of further equipment and subsystems should experience prove it to be vital to the T&E program.

Simulations provide T&E personnel the opportunity to subject men and machines to a much wider variety of test situations than one could normally expect when working with complete systems.

C. LBTS COST/EFFECTIVENESS CONSIDERATIONS

When considering the expenditure of funds required for the establishment and operation of a LBTS, it should be remembered that, with few exceptions, these costs will be incurred <u>anyway</u>, i.e., if not at the LBTS, then somewhere else. The task of proving the integration of the total ship combat system <u>must</u> <u>necessarily</u> be accomplished.

Although the "effectiveness" of a test facility is not amenable to precise definition or measurement, its cost can be defined and estimated with some certainty. If alternatives in execution of a TSTP are limited to T&E at a LBTS or T&E aboard ship, then both alternatives could by definition be "effective" and thus have a constant and equal effectiveness, i.e., they are of "equal benefit" in economic analysis terms.

As previously stated, the costs of the LBTS itself can be determined with some degree of precision. The cost of obtaining a successful T&E via fragmented testing at a diversity of test sites under different managers may only be conjured up. Based on the experiences of past T&E programs such as the DLGN-36, it is postulated that shipboard testing, having as its basis adequate LBTS support, is much less costly. The answer is locked in the future.

D. ADVANTAGES OF LAND-BASED TESTING

Some advantages of utilization of a dedicated LBTS such as that being employed in the PF Program include:

1. Software debug and testing can be accomplished in a controlled hardware environment.

2. System integration debugging can be started earlier since it is not tied to the ship construction schedule and, parenthetically, construction delays.

3. Software debugging can be accomplished in an environment free of industrial work.

4. Use of simulation and simulators can be optimized both on a single project and multi-project levels. One simulator can support more than one system integration effort as can hardware.

5. A single integration facility eliminates redundant test equipment.

6. From the "people" perspective it concentrates your best people at one site. These are the same people that follow the system integration effort through to final ship acceptance.

7. Support software, debug aids, data extraction and reduction and analytical tools can be provided on-site and shared by more than one project.

8. Test site provides earlier "hands on" experience for the nucleus crew and key personnel.

9. GFE software can be "certified" prior to delivery to the contractor shipbuilder.

10. The test site is a step toward satisfying the necessity to develop and retain, permanently, within the Navy, the expertise required to test, evaluate, and integrate a ship combat system.

11. It meets DOD requirements to "fly-before-buy."

E. T&E AND THE PATROL FRIGATE

Admiral Woodfin and others have cited several reasons why the PFCS integration should not proceed down the "primrose path" taken by previous ship acquisitions. The PF Program has integrated total ship testing into the design from the outset. This includes HME, combat system, and mobility. The integrated test program includes: receipt inspection, installation and check out of equipment, equipment testing, intra system tests, inter system tests, builder trials, and acceptance trials. Integration includes utilization of a dedicated

CSLBTS that is a faithful reproduction of the ship. The computer software, combat system integration, and test site development is being performed by one contractor. The tests performed at the test site will be directly transferable to the ship and test site personnel will be involved in the shipboard testing. The PF Program has a combat systems integration manager, responsible for the total system. Finally, the lead ship is being acquired on a cost type contract basis, which will facilitate dealing with integration problems as they occur.

In conclusion, although there is little in major weapon system acquisition that can be predicted with absolute certainty, upon careful consideration, few can deny the legitimacy and fertility of the utilization of a LBTS to reduce uncertainty in ship acquisition testing. "By your test results, ye shall be known", could well serve as a motto for the PFCSLBTS.

F. AREAS FOR FURTHER CONSIDERATION

1. During the time frame that this thesis was being researched and written, the PFCSLBTS was in the process of being built. All of the equipment was not scheduled to have arrived, and the bulk of the equipment at the site was in the process of being powered. Subsystem and system testing obviously had not started. It would be of interest to continue to follow the evolution of the PFCSLBTS through to its final wake, be it at the end of DSARC III, or when the last PF is

decommissioned some thirty years or so hence. Main points for consideration include:

-Did the PFCSLBTS fill its mission to provide the facilities and personnel to test integrated ship combat systems.

-How effective was the LBTS in discovering and correcting (or causing correction), subsystem, interface and computer program problems.

-What was the post audit cost of the test site and did indeed a constant effectiveness situation exist between the LBTS and other viable alternatives.

2. The use of a LBTS and of prototyping has been proposed as an alternative conducive to reducing uncertainty in an acquisition program. A subjective analysis of available alternatives leads one to the conclusion that a LBTS is a viable approach. Would the same results be obtained from a quantitative analysis?

3. Gordon W. Rule in a recent newspaper article, advocated slowing the production schedule of the PF to gain additional time for testing of the Mk 92 FCS, a Dutch designed system, and the Mk 75 gun, an Italian design. Another article reported that the cost of the PF is now about $70 million each, compared with $45 million in 1971. It would be of interest to analyze actual costs with budgeted costs of the PF Program, tempered by inputs such as Mr. Rule's.

APPENDIX A
TEST MODEL FOR ACQUISITION CYCLE

TEST MODEL FOR ACQUISITION CYCLE

ACQUISITION PHASE	CONCEPT FORMULATION	VALIDATION AND RATIFICATION	FULL SCALE DEVELOPMENT	PRODUCTION: INITIAL	PRODUCTION: FULL SCALE	DEPLOYMENT
DEFENSE SYSTEMS ACQUISITION REVIEW COUNCIL (DSARC)		DSARC I	DSARC II	DSARC III		
TESTING CRITERIA	DETERMINE WHETHER: 1. MISSION AND PERFORMANCE ENVELOPES HAVE BEEN ADEQUATELY DESIGNED AND BASED ON MILITARY OBJECTIVES. 2. ACTUAL ENGINEERING DESIGN AND COMPONENT TESTING HAS BEEN DONE TO DEMONSTRATE THAT TECHNICAL RISKS HAVE BEEN ELIMINATED OR REDUCED TO AN ACCEPTABLE LEVEL, 3. PRACTICAL TRADE-OFFS BETWEEN REQUIREMENTS AND ENGINEERING DESIGN HAVE BEEN MADE, AND 4. REAL PROOFING OF CRITICAL COMPONENTS HAS BEEN UTILIZED TO THE GREATEST EXTENT POSSIBLE THROUGH ENGINEERING TESTING.	DETERMINE WHETHER: 1. DESIGNS AND ENGINEERING FOR THE WEAPON SYSTEM HAVE BEEN VALIDATED, AND 2. TECHNICAL AND ECONOMIC BASIS FOR ENTERING FULL-SCALE DEVELOPMENT HAVE BEEN VALIDATED THROUGH DEVELOPMENT OR FABRICATION OF MODELS OR PROTOTYPES WHERE FEASIBLE.	DETERMINE WHETHER: 1. STABILIZED DESIGN AND PERFORMANCE REQUIREMENTS HAVE BEEN ACHIEVED. 2. HARDWARE HAS BEEN PROVEN THROUGH TESTING; 3. ENGINEERING TESTING HAS BEEN COMPLETED. 4. A SYSTEM ACCEPTABLE FOR PRODUCTION, INCLUDING ALL COMPONENTS AND SUBSYSTEMS, HAS BEEN DEVELOPED, AND 5. OPERATIONAL SUITABILITY HAS BEEN REVIEWED WITH A PROTOTYPE OR AT LEAST A MOCK-UP.	DETERMINE WHETHER: 1. PRODUCIBILITY HAS BEEN VERIFIED, 2. COMPLETE AND ADEQUATE DOCUMENTATION HAS BEEN PROVIDED; 3. SUFFICIENT QUANTITIES TO PERMIT TEST AND EVALUATION AND TO CORRECT DESIGN DEFECTS WHICH EFFECT PRODUCTION HAVE BEEN PROVIDED, AND 4. OPERATIONAL SUITABILITY OF A PRODUCTION ARTICLE HAS BEEN TESTED.	DETERMINE WHETHER: 1. CONFIGURATION OF THE WEAPON SYSTEM HAS BEEN FIRMLY ESTABLISHED; 2. ACCEPTANCE TESTING AND CERTIFICATION OF COMPONENT SUBSYSTEMS, AND COMPLETE SYSTEMS HAVE BEEN PROVIDED, AND, 3. COMPLETED SYSTEM HAS ACHIEVED PERFORMANCE GOALS AS CONTRACTED.	DETERMINE WHETHER: 1. USER HAS ACCEPTED A WEAPON SYSTEM WITH THE DESIRED CAPABILITY; 2. USER HAS VERIFIED IF THE WEAPON, MEN, AND TACTICS WILL PERFORM IN THE MANNER INTENDED, THROUGH OPERATIONAL SUITABILITY TESTING; AND 3. MAINTAINABILITY AND RELIABILITY STANDARDS HAVE BEEN ACHIEVED.
RESPONSIBLE PARTIES PRIMARY ▲ SECONDARY ○ MONITOR ●	DEVELOPER ▲ USER ○	DEVELOPER ▲ CONTRACTOR ○ USER ●	CONTRACTOR ▲ DEVELOPER ○ USER ●	DEVELOPER ▲ USER ○ CONTRACTOR ●	CONTRACTOR ▲ DEVELOPER ○ USER ●	USER ▲ DEVELOPER ○ CONTRACTOR ●
BASIC TESTING CATERGORIES	ENGINEERING TESTING	ENGINEERING TESTING	ENGINEERING TESTING	ACCEPTANCE TESTING / OPERATIONAL SUITABILITY TESTING	ACCEPTANCE TESTING / OPERATIONAL SUITABILITY TESTING	OPERATIONAL SUITABILITY TESTING

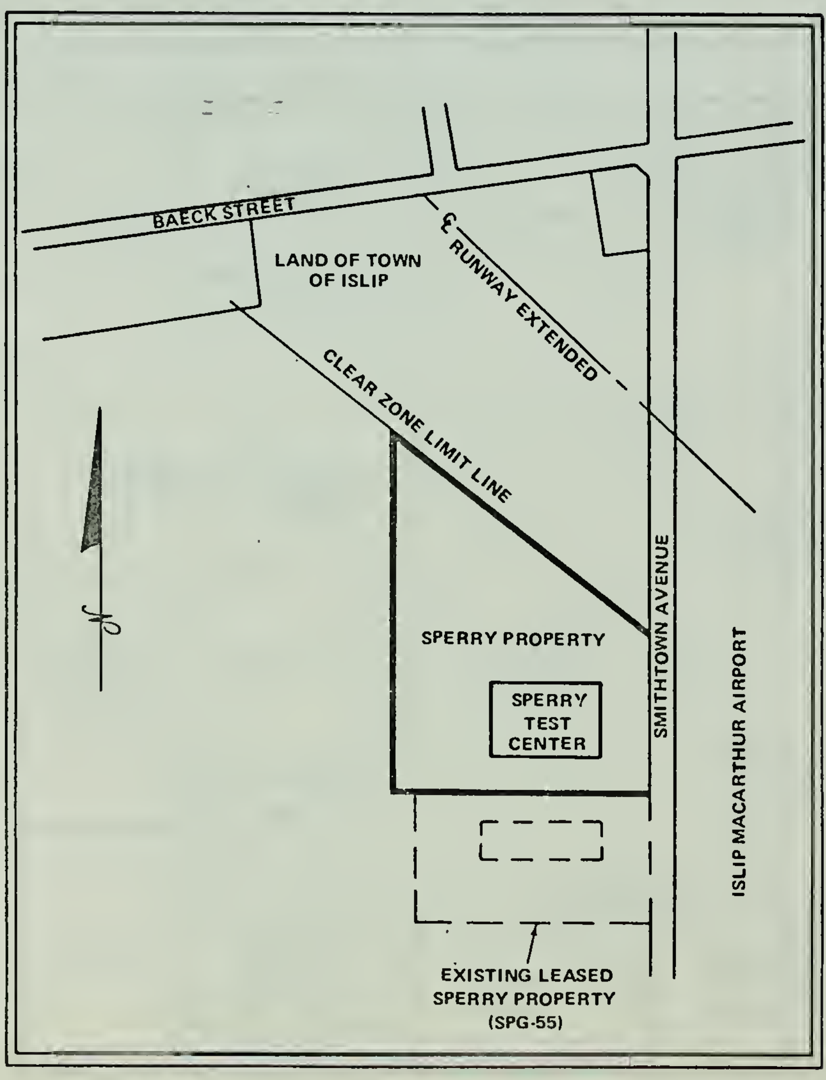
APPENDIX B
THE PF COMBAT SYSTEM/SPERRY TEST CENTER

PF COMBAT SYSTEM

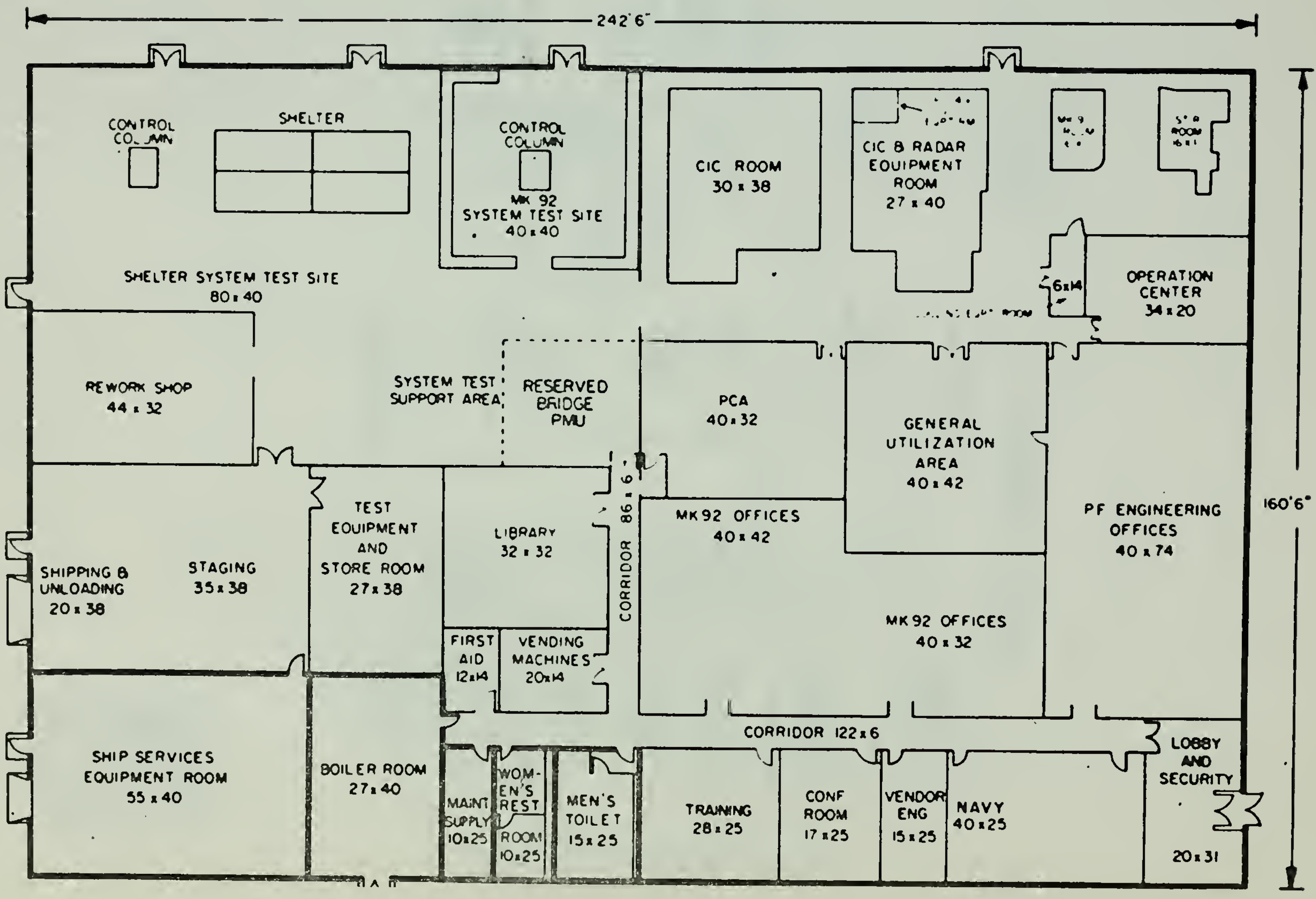
SPERRY TEST CENTER

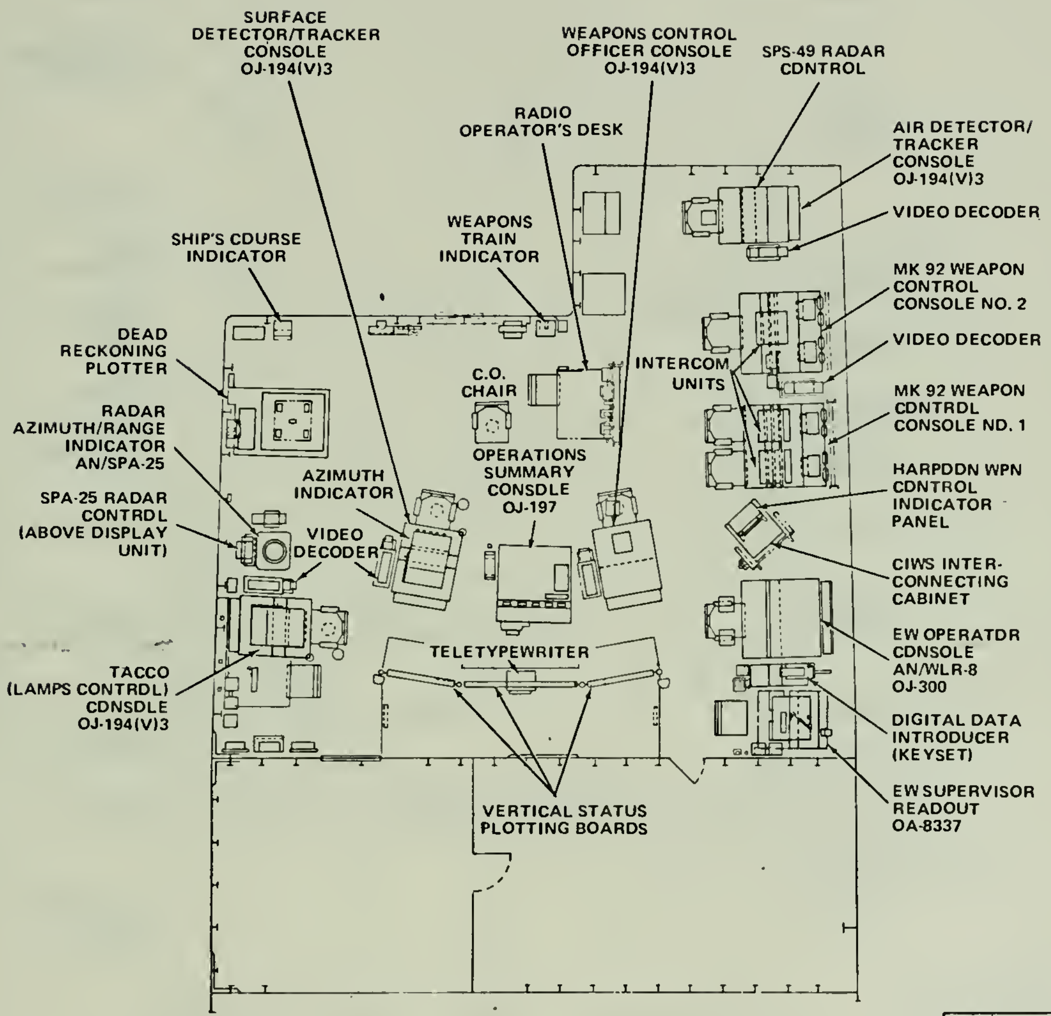
MacArthur Field, L.I.

SPERRY AT MAC ARTHUR FIELD

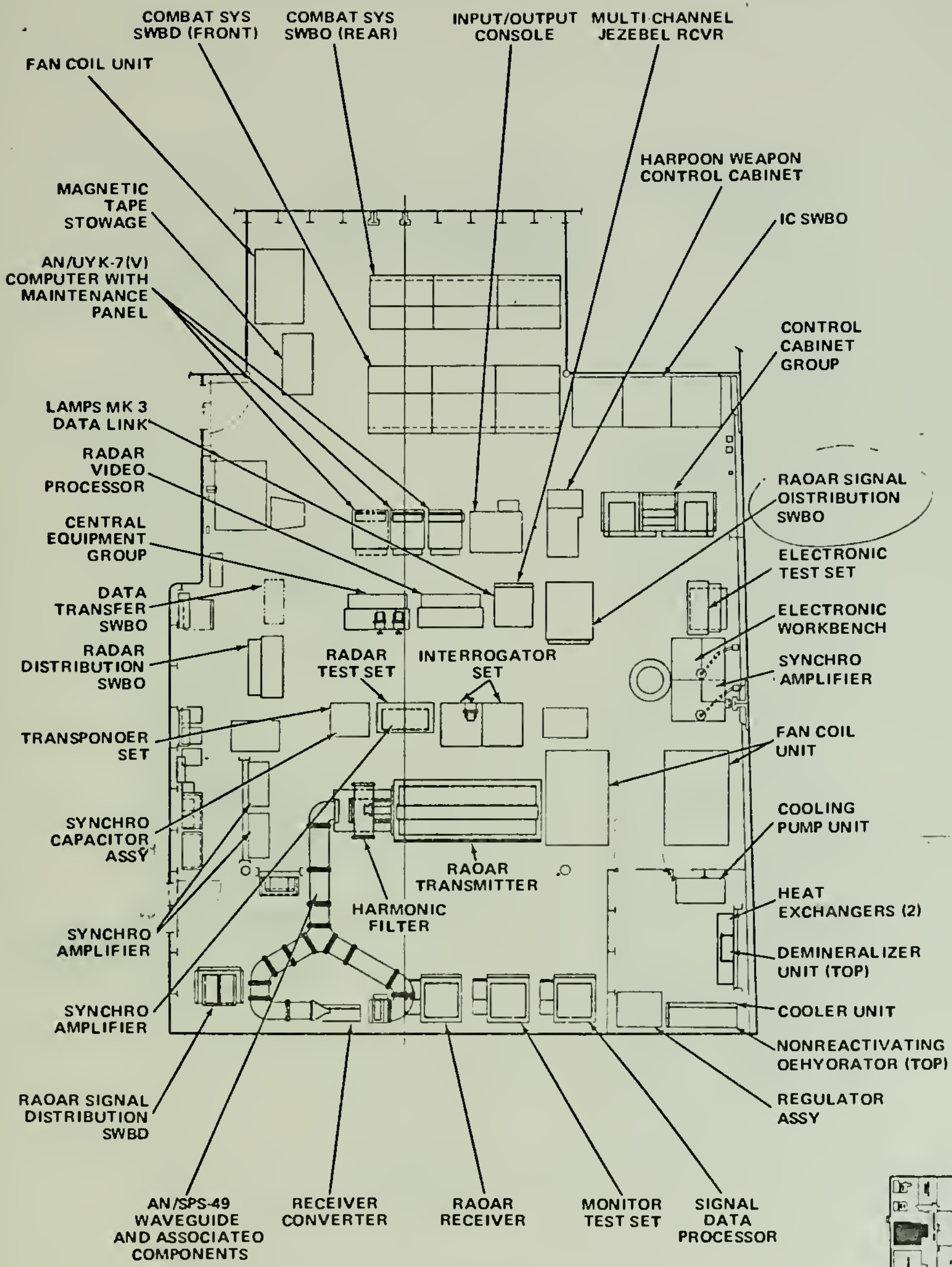


SYSTEM TEST CENTER FLOOR PLAN



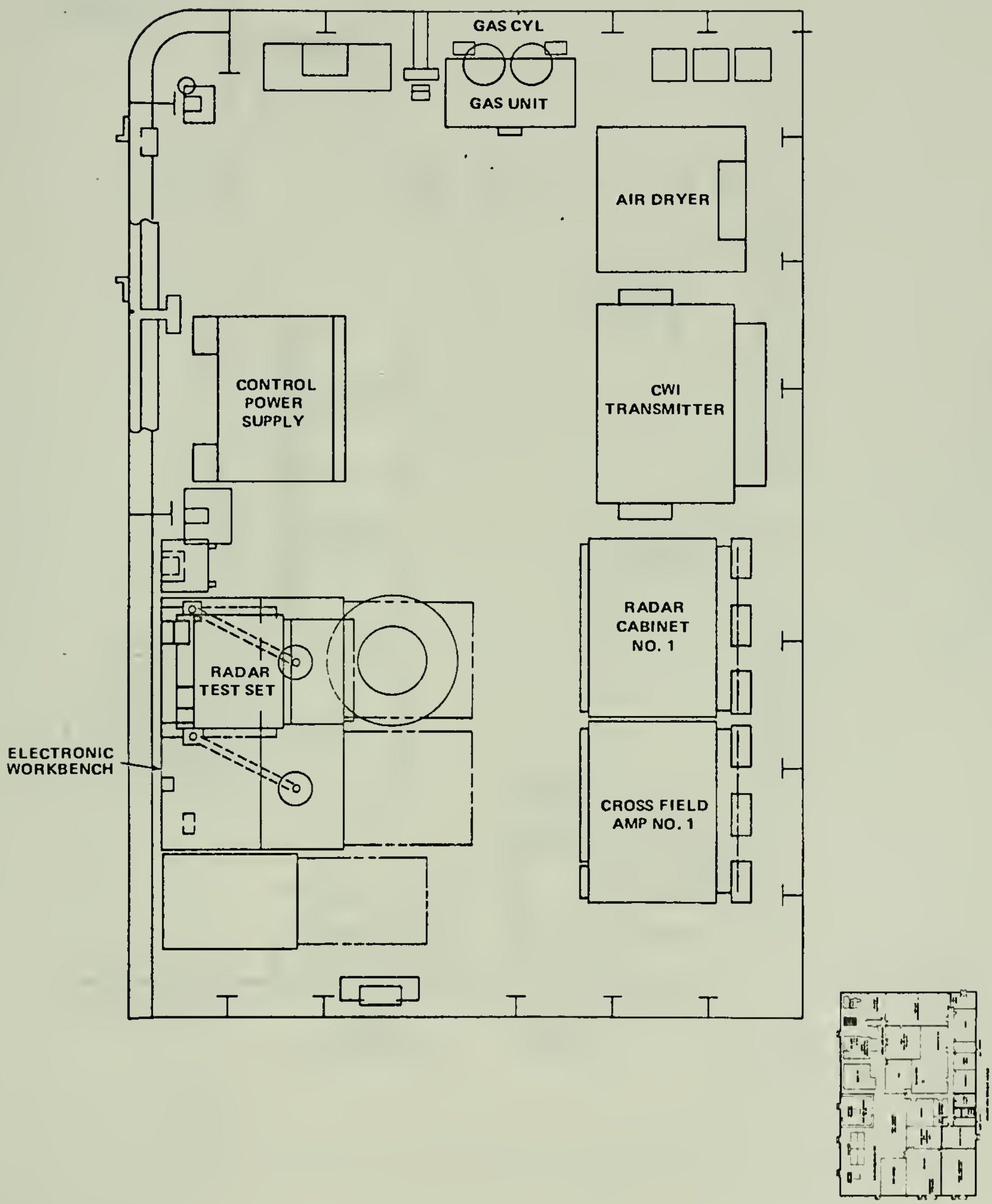


CIC AND SONAR CONTROL ROOM

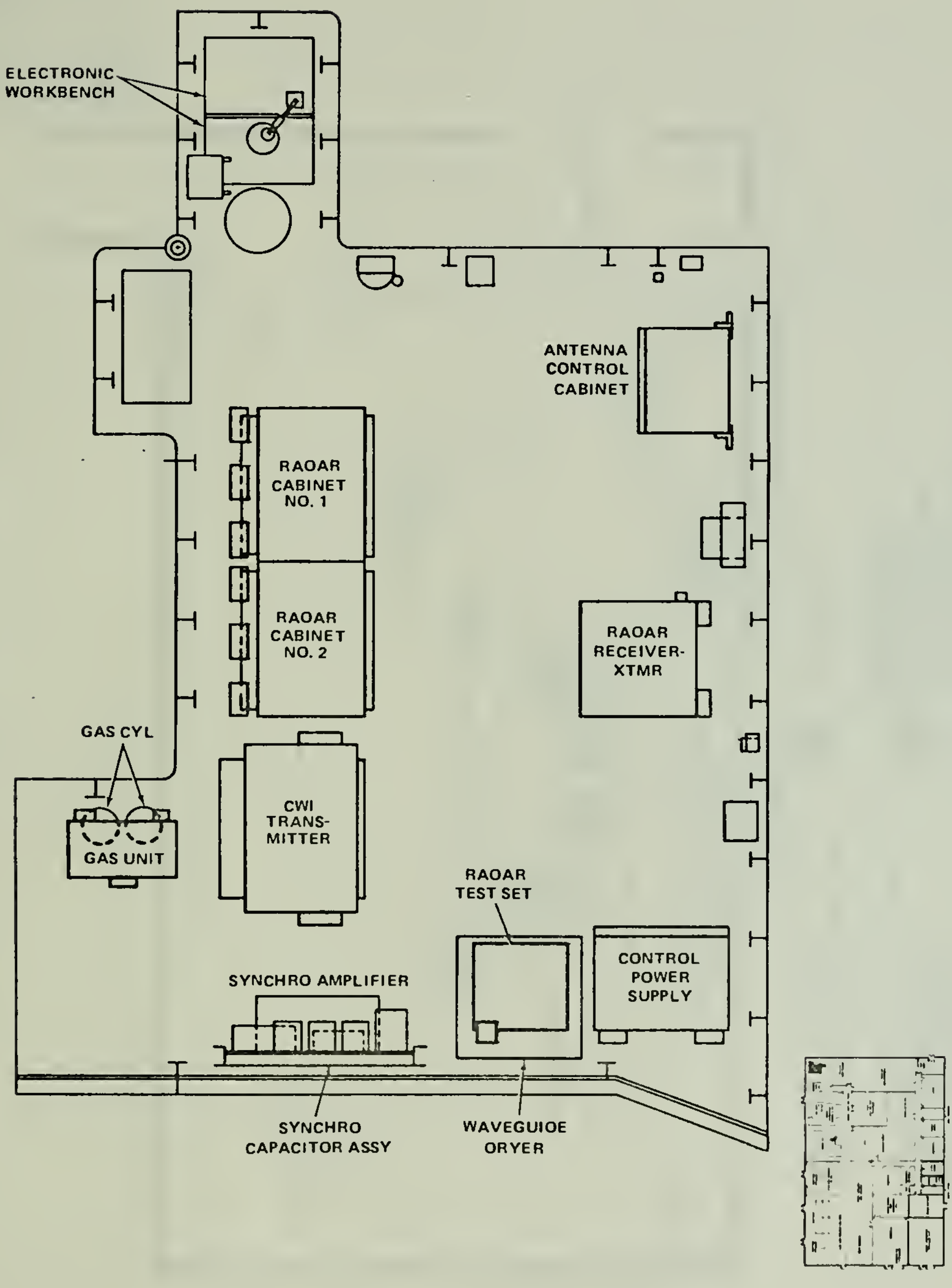


CIC, IFF AND SONAR EQUIPMENT ROOM

105

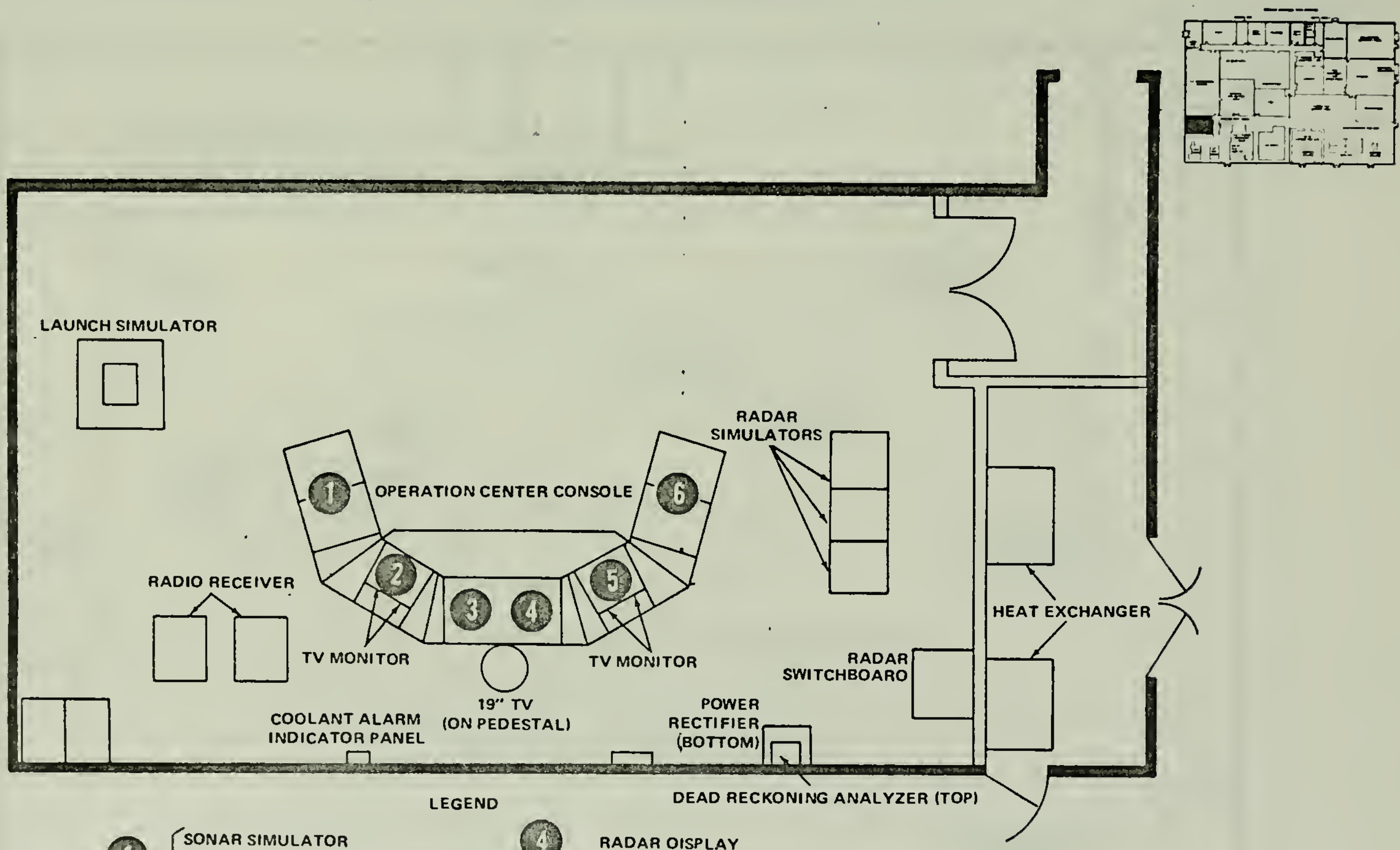


MK-92 EQUIPMENT ROOM



STIR EQUIPMENT ROOM

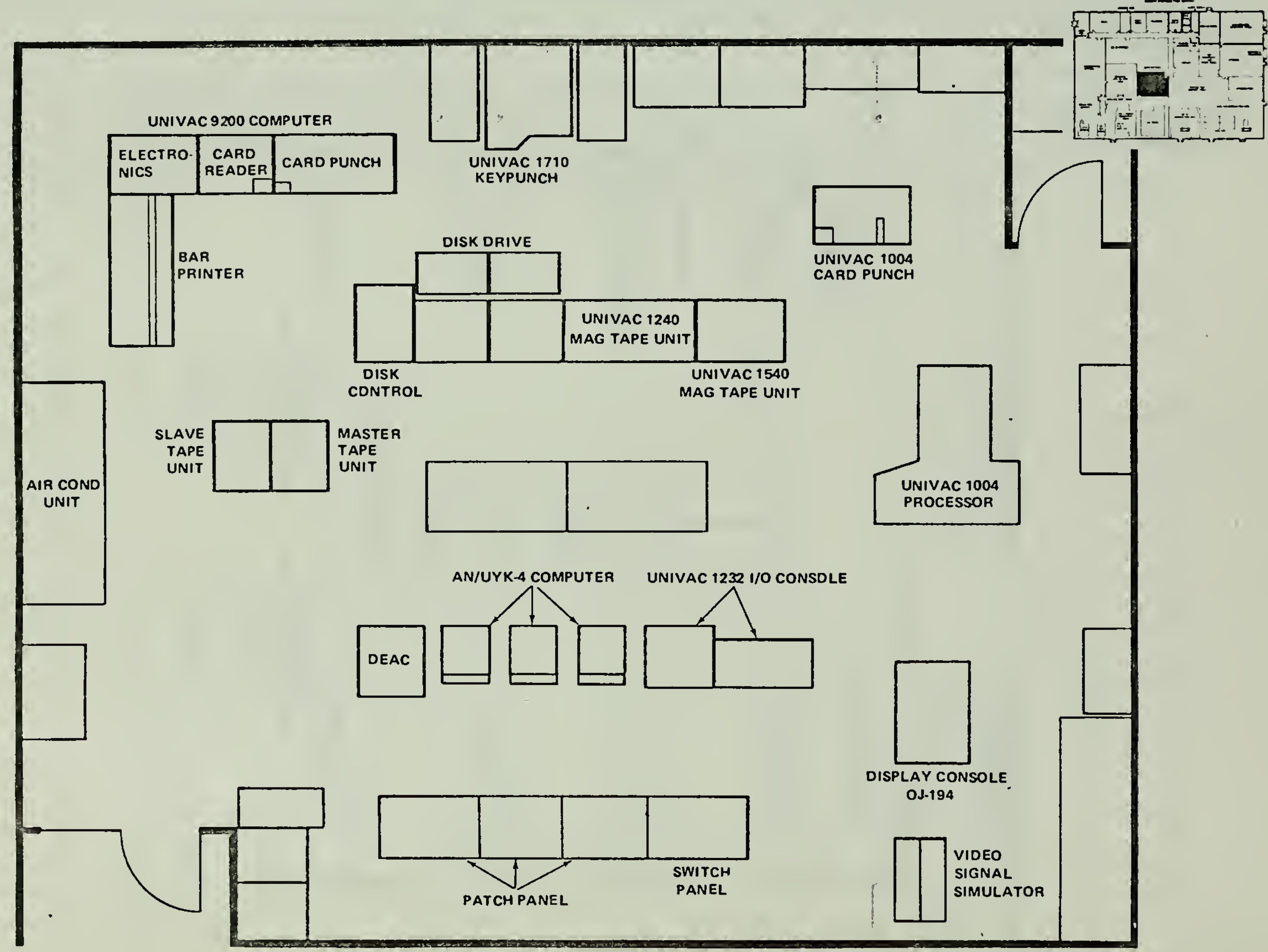
OPERATIONS CENTER



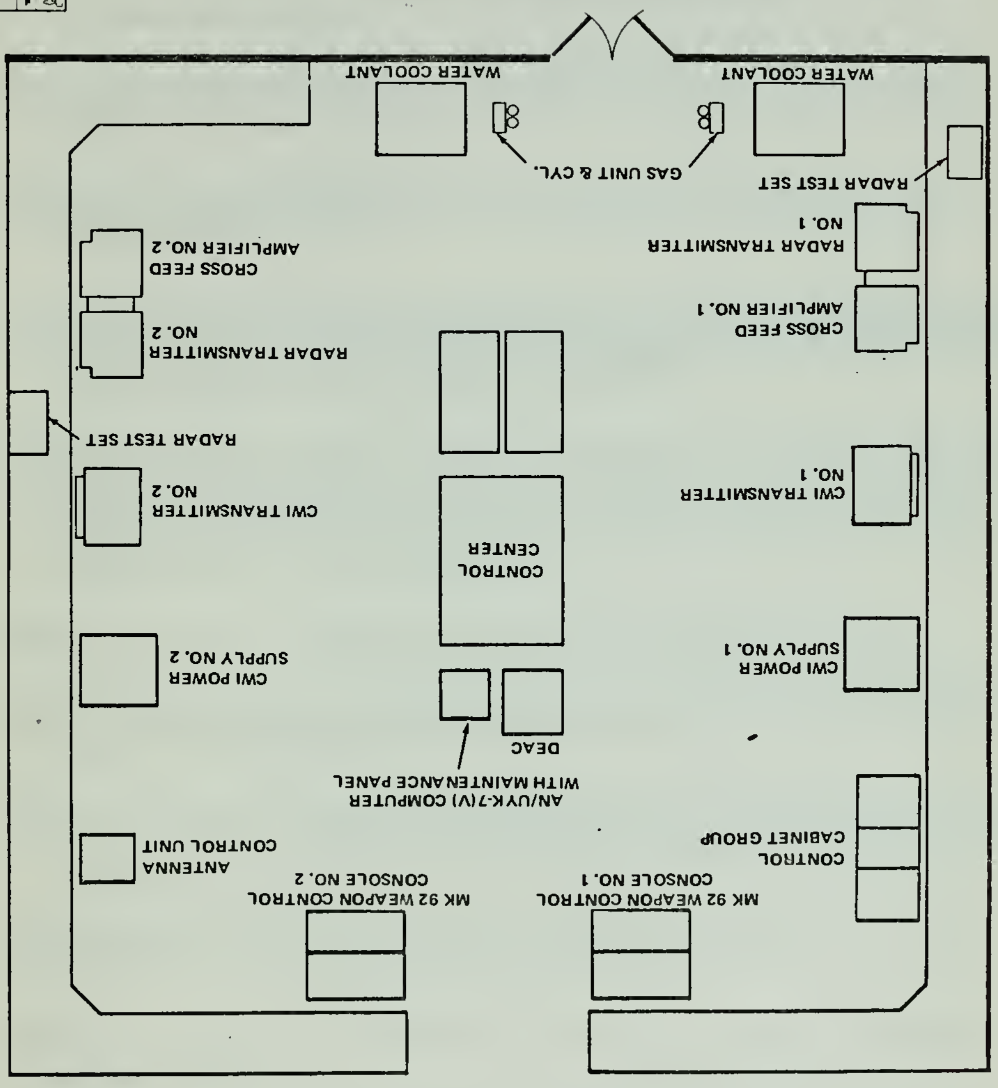
LEGEND

1. SONAR SIMULATOR, HEADING & SPEED SIMULATOR, MISSILE SIMULATOR
2. PROJECTION DISPLAY PANEL, CONTROL PANEL, CAMERA CONTROL, S/O CONVERTER, COMPUTER INTERFACE
3. CRT DISPLAY
4. RADAR DISPLAY
5. MONITOR PANEL, CAMERA CONTROLS, VIDEO SWITCHER, LAUNCHER SIMULATOR, GUN SIMULATOR, VIDEO DISTRIBUTION PANEL
6. VIDEO & AUDIO TAPE RECORDER

PROGRAM CHECKOUT AREA (PCA)



MK-92 TEST SITE



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